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ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS WORLDWIDE

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A CAHNERS PUBLICATION

May 27, 1993

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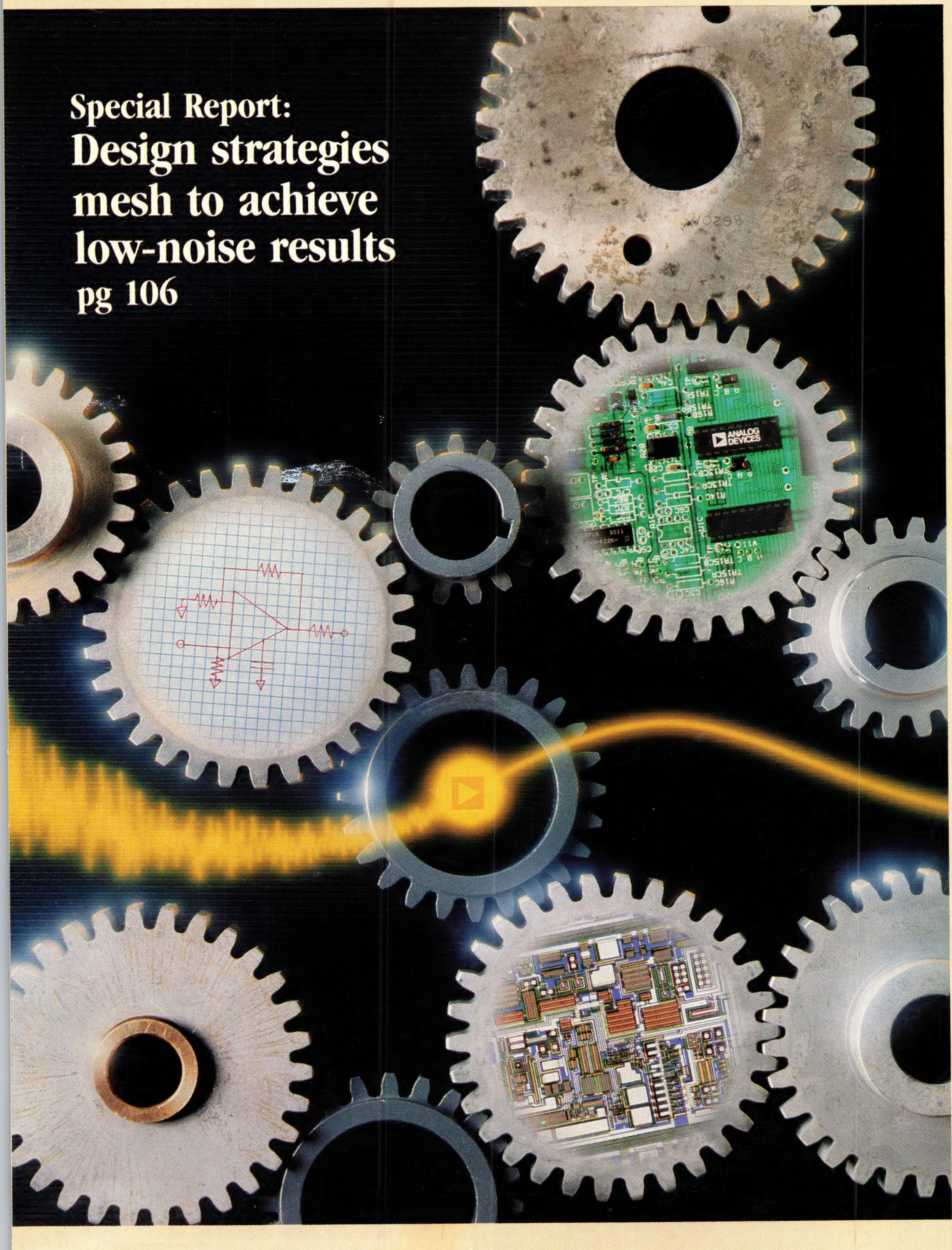
Design strategies mesh to achieve low-noise results
pg 106



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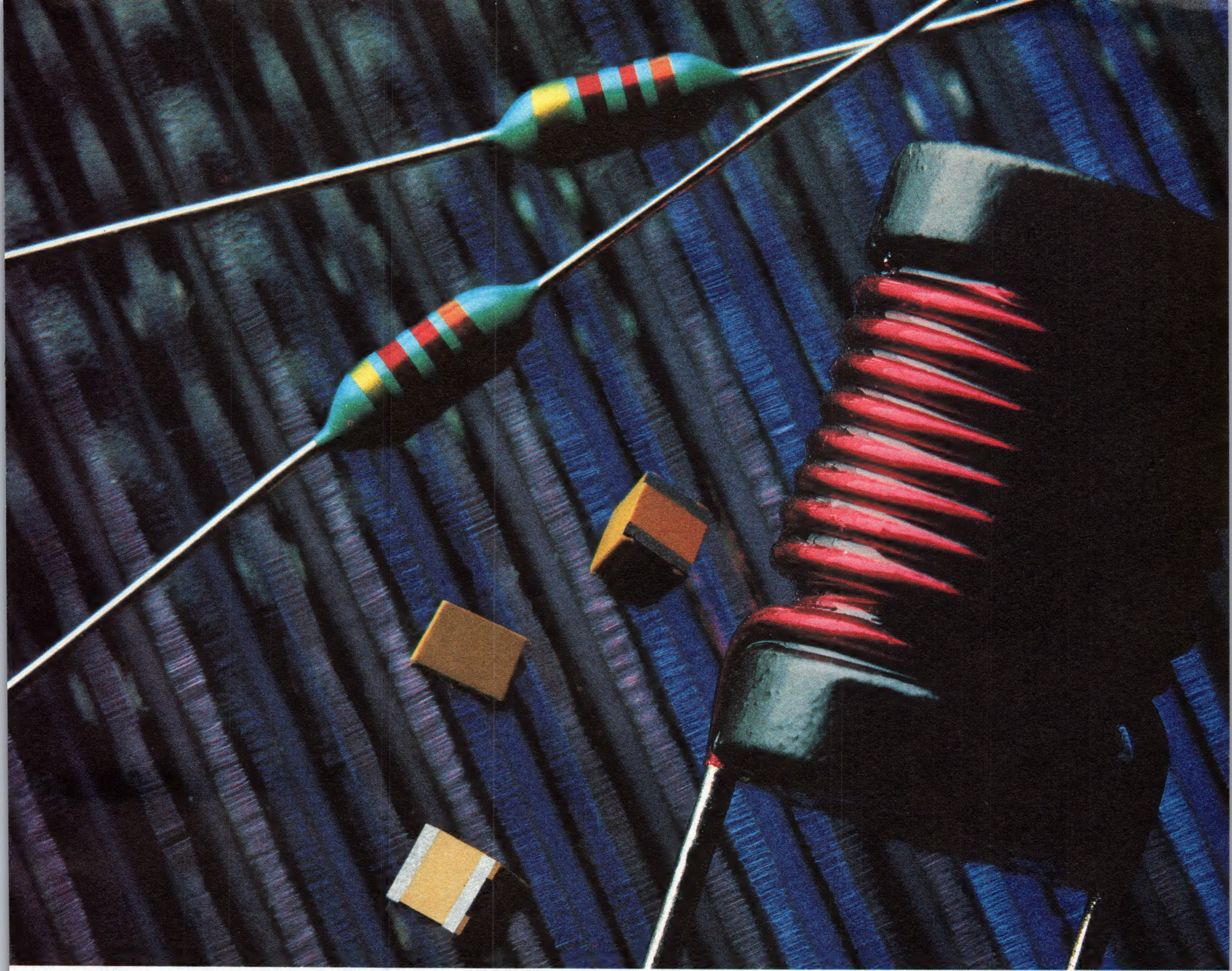

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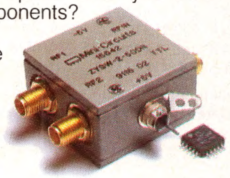

SPECIFICATIONS (typ)	Absorptive SPDT YSWA-2-50DR ZYSWA-2-50DR			Reflective SPDT YSW-2-50DR ZYSW-2-50DR		
Frequency (MHz)	dc-500	500-2000	2000-5000	dc-500	500-2000	2000-5000
Ins. Loss (dB)	1.1	1.4	1.9	0.9	1.3	1.4
Isolation (dB)	42	31	20	50	40	28
1dB Comp. (dBm)	18	20	22.5	20	20	24
RF Input (max dBm)	—	20	—	22	22	26
VSWR "on"	1.25	1.35	1.5	1.4	1.4	1.4
Video Bkthru (mV,p/p)	30	30	30	30	30	30
Sw. Spd. (nsec)	3	3	3	3	3	3
Price, $ (1-9 qty)	YSWA-2-50DR (pin) 23.95 ZYSWA-2-50DR (SMA) 69.95			YSW-2-50DR (pin) $14.95 ZYSW-2-50DR (SMA) 59.95		

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F141 REV. D

CIRCLE NO. 16

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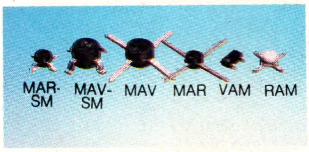


Models above shown actual size

from **99¢** Unit price $ (25 qty)

PLASTIC SURFACE-MOUNT			++VAM-3 1.45		+VAM-6 1.29	++VAM-7 1.75		
add suffix SM to model no. (ex. MAR-ISM)	MAR-1 1.04	MAR-2 1.40	MAR-3 1.50	MAR-4 1.60	MAR-6 1.34	MAR-7 1.80	MAR-8 1.75	
	MAV-1 1.15	+MAV-2 1.45	+MAV-3 1.55	MAV-4 1.65				MAV-11 2.15
CERAMIC SURFACE-MOUNT	RAM-1 4.95	RAM-2 4.95	RAM-3 4.95	RAM-4 4.95	RAM-6 4.95	RAM-7 4.95	RAM-8 4.95	
PLASTIC FLAT-PACK	MAV-1 1.10	+MAV-2 1.40	+MAV-3 1.50	+MAV-4 1.60				MAV-11 2.10
	MAR-1 0.99	MAR-2 1.35	MAR-3 1.45	MAR-4 1.55	MAR-6 1.29	MAR-7 1.75	MAR-8 1.70	
Freq.MHz,DC to	1000	2000	2000	1000	2000	2000	1000	1000
Gain, dB at 100MHz	18.5	12.5	12.5	8.3	20	13.5	32.5	12.7
Output Pwr. +dBm	1.5	4.5	10.0	12.5	2.0	5.5	12.5	17.5
NF, dB	5.5	6.5	6.0	6.5	3.0	5.0	3.3	3.6

Notes: + Frequency range DC-1500MHz ++ Gain 1/2 dB less than shown

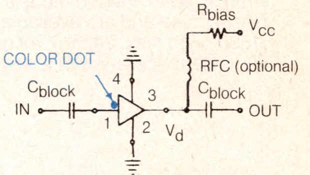
designer's amplifier kits
DAK-2: 5 of each MAR-model (35 pcs), only $59.95
DAK-2SM: 5 of each MAR-SM model (35 pcs) only $61.95
DAK-3: 3 of each MAR, MAR-SM, MAV-11, MAV-11SM (48 pcs) $74.95

designer's chip capacitor kit
KCAP-1: 50 of 17 values, 10pf to 0.1μf (850 pc), $99.95

chip coupling capacitors at .12¢ each (50 min.)

Size (mils)	Value
80 x 50	10, 22, 47, 68, 100, 220, 470, 680 pf
80 x 50	1000, 2200, 4700, 6800, 10,000 pf
120 x 60	.022, .047, .068, .1μf

Typical Circuit Arrangement



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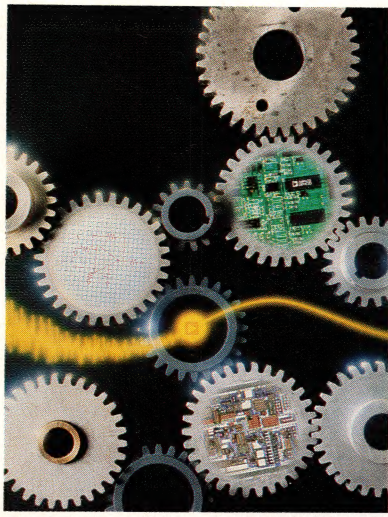
F154 REV. A

CIRCLE NO. 17

EDN

May 27, 1993 VOLUME 38, NUMBER 11

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS WORLDWIDE



On the cover: New and improved analog, digital, and mixed analog/digital designs offer a world of opportunity to design engineers but also present traditional noise problems. Analog designers have devised methods that all engineers can employ to deal with unwanted signals. (Photo courtesy Analog Devices)

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ANALOG TECHNOLOGY SPECIAL ISSUE

SPECIAL REPORT

Noise vs sensitive circuits — 106

Naturally occurring noise continues to be just as nasty a problem as ever.—*Charles H Small, Senior Technical Editor*

DESIGN FEATURES

Designer's guide to single-supply analog design—Part 1 — 119

This 2-part series focuses on designing using devices and techniques that extract the maximum benefit from single power supplies.
—*Walt Jung and James Wong, Analog Devices Inc*

Measuring transient voltages between separate ground points — 131

Knowing how to make scope measurements of ground potentials can put your circuit on a fast road to recovery.—*Art Porter, Hewlett-Packard Co*

TECHNOLOGY UPDATE

Close data-sheet scrutiny ferrets out true performance specs — 61

Most analog-component data sheets contain the information you need if you know where to look and what to look out for.—*Anne Watson Swager, Technical Editor*

Analog products special section — 79

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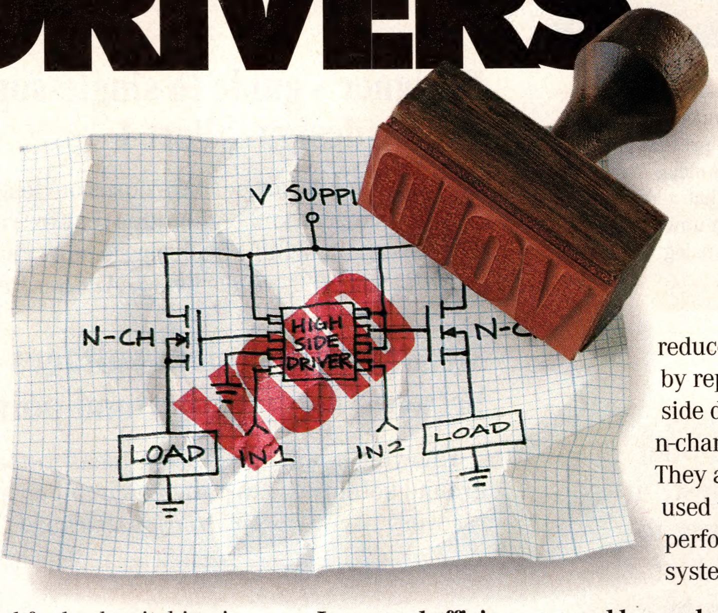
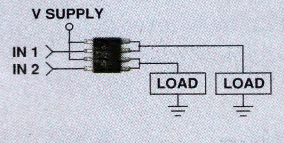
What will Siliconix' new 3-V p-channel MOSFETs do to help shrink system size?

STAMP OUT HIGH-SIDE DRIVERS



With leakage currents of only 1 μA, these new LITTLE FOOT® devices are the industry's most efficient 3-V solutions. They're unequalled for design simplicity, power efficiency, small size, and cost effectiveness. And ideal for load switching in portable computers and cellular phones.

LITTLE FOOT SO-8 POWER MOSFETs



Device	Breakdown Voltage (V)	On-Resistance (Ω)	Current (A)
Si9433DY single p-ch	-12	0.075 @ V_{GS} = -4.5V	±5.1
	-12	0.110 @ V_{GS} = -2.7V	±4.0
Si9933DY dual p-ch	-12	0.13 @ V_{GS} = -4.5V	±3.8
	-12	0.21 @ V_{GS} = -2.7V	±3.0

Simplified load switching ... no high-side driver. These new p-channel devices operate directly from 3-V logic supplies or batteries. They simplify design and reduce part count by replacing a high-side driver IC and an n-channel MOSFET. They also can be used to enhance the performance of 5-V systems.

Increased efficiency ... and longer battery life. Both the new surface-mount Si9433 and the Si9933 draw far less power than the typical high-side driver/n-channel solution. And they have low voltage drop as well, so no heat sink is required.

Designing small ... a big advantage. These power dense SO-8 LITTLE FOOT devices significantly shrink system size. So, get small.... contact your local TEMIC/Siliconix sales office. Or call our toll-free hot line now! **1-800-554-5565, ext. 977.** Ask for your "3-V LITTLE FOOT" Design Kit.

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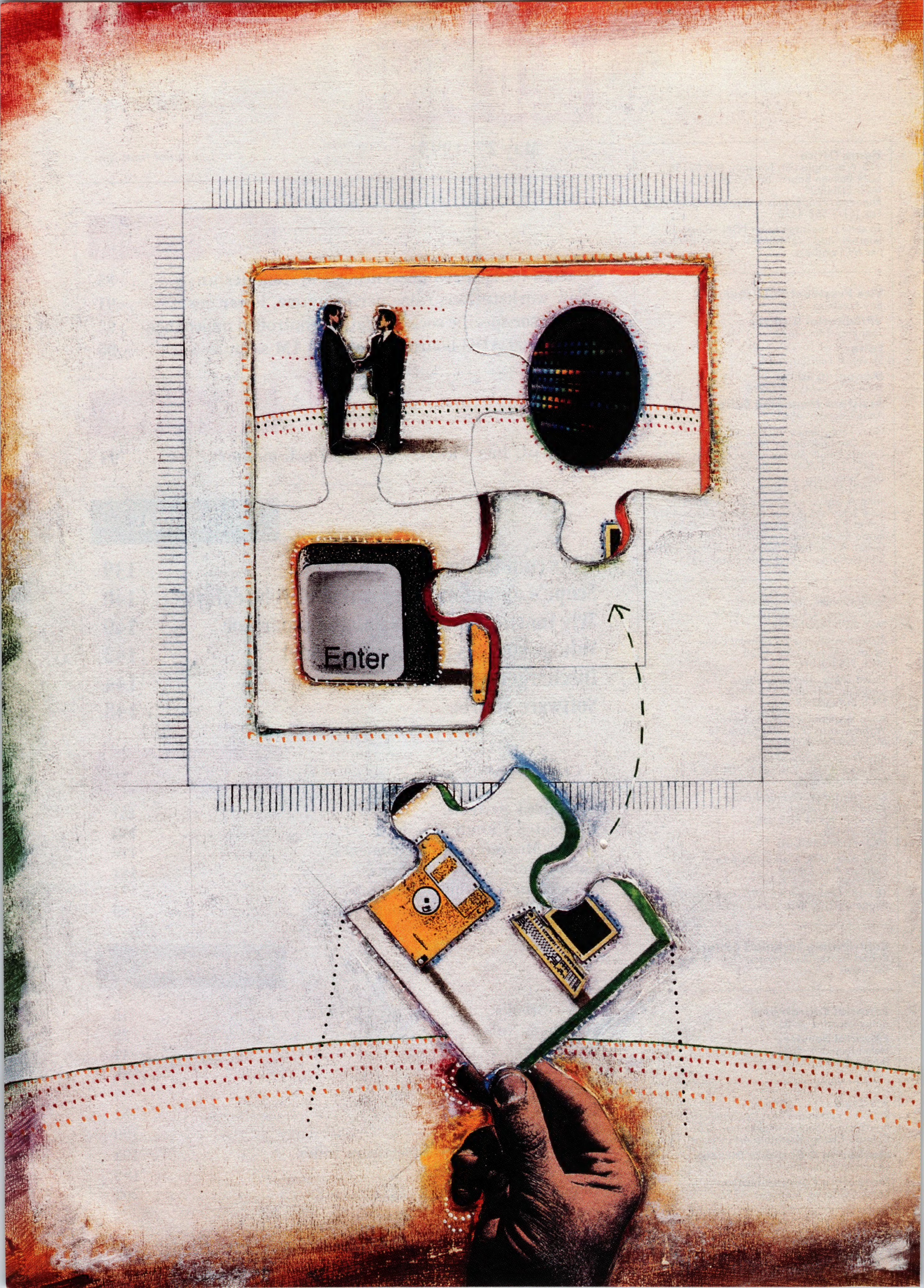
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Model Number	Equiv. Gates	Macro Cells	Max. Delay	System Speed	I/O Pins
MACH 435	**5000**	**128**	**15ns**	**50 MHz**	**84**
MACH 230	3600	128	15ns	50 MHz	84
MACH 130	1800	64	15ns	50 MHz	84
MACH 220	2400	96	15ns	50 MHz	68
MACH 120	1200	48	15ns	50 MHz	68
MACH 210	1800	64	12ns	66.7 MHz	44
MACH 110	900	32	12ns	66.7 MHz	44

So when your next design requires a heavy-weight PLD that does the impossible on a regular basis, look up the new MACH family of high-density PLDs. For more information, call AMD today.

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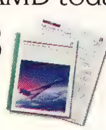

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CIRCLE NO. 128

EDITED BY SUSAN ROSE

Boards turn PCs into TIAs

Time-interval analyzers (TIAs), or as some vendors call them, modulation-domain analyzers, are to frequency counters what scopes are to multimeters. If you need to observe how voltages vary as a function of time, a scope is much more appropriate than a meter. Similarly, if you need to observe how time intervals or frequencies vary vs time, a TIA is more appropriate than a counter—at least if the variations are rapid. Until now, if you wanted a TIA capable of gap-free measurement, your choices were restricted to instrument-level products and a few VXIbus modules. Guide Technology, however, has announced a family of five ISA bus boards that turn PCs into TIAs.

Compared with TIAs packaged as stand-alone instruments, the new products are less expensive, have more memory (as much as 2000× more), and transfer data to the host PC about 20× as fast. In addition, two of the boards have 16 channels, whereas the stand-alone products usually have no more than two. The 16-channel capability easily permits measurements that previously weren't possible, or at least required massive amounts of test equipment. An example is measuring the uniformity of mechanical parts' positioning in a developmental internal-combustion engine as its speed and load vary. **Table 1** lists the model lineup and base pricing with 32 kbytes of measurement memory and software drivers. Memory is expandable to 2 Mbytes on the base board and to 64 Mbytes using a plug-in board. Note that with TIAs, aliasing will not occur unless the modulation (not the carrier frequency) contains components at frequencies exceeding half the sampling rate. It is entirely appropriate to use a TIA that takes 2M samples/sec to measure changes at frequencies below 1 MHz in the frequency of a 2-GHz signal.—by Dan Strassberg

Guide Technology, San Jose, CA, (408) 246-9905, fax (408) 246-0924, contact Shalom Kattan. **Circle No. 509**

Table 1—Guide Technology's ISA-bus-board family

Model	Number of Channels	Frequency Range	Msamples/sec sampling	Resolution	US Price
GT651	2	dc to 400 MHz[1]	10	100 psec	$13,500
GT654	2	dc to 400 MHz[1]	2	100 psec	$7000
GT655	2	dc to 400 MHz[1]	2	2 nsec	$5500
GT657	16	dc to 25 MHz	25/50	20 nsec	$8000
GT659	16	dc to 25 MHz	2	20 nsec	$6000

Note:
1. 2 GHz optional.

Accurate digital models available for free

Intel's IBIS program promises to let digital-IC companies give away accurate circuit-level models of their devices. Increasingly, digital engineers must perform a successful signal-integrity simulation of a digital design before signing it off.

But, IC makers have a tricky problem to solve before they can pass out models without giving away the farm. An accurate model can reveal proprietary design information to the IC makers' competitors. Under IBIS, simulation-software vendors will be able to generate models directly from the device maker's data.

According to Intel, the following simulation-software vendors have agreed to support IBIS: Hyperlynx, Redmond, WA, (206) 867-2320; Integrity Engineering, St Paul, MN, (612) 636-6913; Intusoft Inc, San Pedro, CA, (310) 833-0710; Meta-Software Inc, Campbell, CA, (408) 371-5100; MicroSim Corp, Irvine, CA, (714) 770-3022; Quad Design, Camarillo, CA, (805) 988-8250; and Quantic Laboratories, Winnepeg, MB, Canada, (204) 942-4000.

Currently, Intel's only examples of IBIS models are in its "Pentium Processor Open Design Guide," chapter 17. For a copy, call (800) 548-4724 and ask for order number 297267-001 (no charge).

—by Charles H Small

Intel Corp, Santa Clara, CA, (800) 548-4724. **Circle No. 511**

Fuzzy-logic chip compares patterns

A new fuzzy-logic IC from American Neuralogix Inc is dedicated specifically to pattern comparison. It works in systems that recognize physical objects, characters, spoken words, fingerprints, or currencies.

The NLX-110 Fuzzy Pattern Comparator compares eight unknown patterns to one reference or eight references to a single unknown. Because it uses fuzzy logic, the chip is especially suited to comparisons of noisy, jittery, skewed, or inaccurate data streams. The 66-pin IC accepts eight serial data patterns at rates as high as 20 MHz. The chip costs $15.42 (10,000), and PC-based development software sells for $395.

—by Gary Legg

American Neuralogix Inc, Sanford, FL, (407) 322-5608, fax (407) 322-5609. **Circle No. 512**

Foot-long IC produces plotter output

Xerox Engineering Systems is using foot-long, amorphous-silicon ICs as writing devices in new electrostatic plotters.

The 0.5-in.-wide ICs have 400-dpi "nibs," or writing points, that hold charge longer than nibs in wire-wound writing heads. Three of the ICs connect end-to-end in a plotter's writing head to generate 3-ft-wide drawings.

The use of amorphous silicon, rather than crystalline silicon, for write-head ICs allows closely spaced circuits that are isolated from each other. That isolation improves plot quality relative to other plot technologies.—by Gary Legg

Xerox Engineering Systems, Stamford, CT, (203) 968-3000.

Circle No. 513

Motion controller boosts disk density

In an effort to become a complete supplier for the disk-drive industry, Cirrus Logic has introduced a motion-control IC that provides all the functions needed for head positioning. The company already offers drive-controller, read/write-channel, and servo-controller devices.

The motion-control device, the CL-SH7200, combines a DSP core with program memory, servo-sequencer logic, sector-pulse-generator logic, and the ADCs and DACs needed to sense and change head position. The combination fits into a 100-pin thin quad flatpack (TQFP). The on-chip DSP core is capable of processing 10M instructions/sec, making it fast enough to handle the servo-data rates needed for 4000-track/in. densities. Samples cost $25 (1000); production is scheduled for the third quarter of 1993.

—by Richard A Quinnell

Cirrus Logic, Fremont, CA, (510) 226-2339, fax (510) 226-2240.

Circle No. 514

IC emulator offers time-saving improvements

New software and hardware options for Quickturn's Enterprise Emulation systems are targeting specific user needs. Modular Emulation software reduces the time needed to make bug fixes and continue emulation. Synthesis users who fix a bug and resynthesize the design may end up with a completely different gate-level netlist. The new software limits the change to a single module in the emulator, reducing reconfiguration time.

The Picasso Emulation subsystem lets you emulate graphics systems with an interface to CRT displays. The system provides monitor resolutions as high as 1280 × 1024 pixels. The emulator accepts 24-bit digital or analog color signals from the graphics subsystem under emulation. You can display the images on a full-resolution video monitor at speed.

New emulation-server models 500 and 1200 let you emulate multiple designs simultaneously and remotely over a network. Entry-level systems cost less than $100,000.

—by Doug Conner

Quickturn Systems Inc, Mountain View, CA, (408) 967-3300, fax (408) 967-3199. **Circle No. 515**

ATPG tool evaluates path delay in 1M-gate ASICs

As ASICs become more complex, the tools that create the designs yield parts whose path-to-path delay variations are smaller than those of earlier devices. The result is that the number of critical delay paths per device is increasing faster than the number of gates per device—and the number of gates per device is increasing rapidly. The escalation in the number of critical delay paths heightens the importance of timing simulation. ASIC designers used to try to avoid timing simulation because generating the test vectors took too long and consumed too much workstation power. In newer designs, however, avoiding timing simulation can lead to designs that don't work, and failure to perform at-speed tests on production devices can lead to unacceptable rates of device failures in systems.

Beginning this summer, ASIC designers will have a tool that harnesses the distributed computing power of multiple networked workstations and reduces test-development times from previous norms by a factor of 20. Aida II is a software tool for automatic test-pattern generation (ATPG). It is the successor to Aida, which has been used on more than 500 completed designs. The new tool uses an advanced delay-path algorithm called Adept that permits delay testing without the insertion of scan latches or boundary-scan elements. The result is improvements of 50% or more in die utilization and a 10% speed improvement. For production-device tests, you can convert the timing vectors to a form that runs on newer high-speed ASIC-test systems. The US list price begins at $90,000 per copy. Licenses for additional network nodes cost from $15,000 each for two nodes, to $5000 each for six nodes or more; users of Aida can upgrade for $40,000.

—by Dan Strassberg

CrossCheck Technology, San Jose, CA, (408) 432-9200, fax (408) 432-0907. **Circle No. 516**

IBM enters ASIC merchant market

As part of its restructuring plan, IBM has developed independent business units to market its advanced technology to the rest of the industry. One such business unit, IBM Technology Products ASIC Division, now

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has a number of high-performance ASIC processes available for designers, as well as design tools compatible with most popular IC CAD systems. The unit is establishing independent design centers for customer use on both coasts of the US.

The company's technology is geared to high-performance designs. Its 3.3V CMOS gate arrays use 0.5-μm lithography and incorporate 4- or 5-layer metal interconnections. In addition, the company's packaging techniques let you place solder "bumps" on the die, then mount the die face-down on an interconnection substrate. This technique lets I/O pads be located anywhere on the IC, eliminating die-size-based restrictions on I/O pin count. Designs can be as large as 1,240,000 usable gates with 1172 I/O ports. The company can produce prototypes using its technology and has scheduled production for 1994.
—by Richard A Quinnell

IBM Technology Products, Somers, NY, (914) 765-6630. **Circle No. 517**

PCMCIA gathers momentum

Products adhering to PCMCIA (Personal Computer Memory Card International Association) standards are finally preparing to enter the commercial mainstream. At this week's Comdex in Atlanta, more computers than ever will have slots for the credit-card-sized PCMCIA cards, or PC Cards. More importantly, many of those computers will also have system software that fully supports the cards.

Although PC Cards proliferated within the past year, the lack of fully operational system software prevented most computers from using cards interchangeably. Now, Award Software International Inc has joined Systemsoft Corp as a second supplier of fully PCMCIA-compliant system software. PCMCIA software, when combined with PCMCIA hardware features, provides "plug and play" capabilities such as "hot" (power-on) card swapping and dynamic system reconfiguration.

Chip makers are also making it easier to add PCMCIA card slots to a system. Vadem announced three new host-adapter ICs this month; Texas Instruments announced a 4-slot interface IC last month. These companies join Intel Corp (Folsom, CA), Cirrus Logic Inc (Fremont, CA), and Databook Inc (Rochester, NY) as host-adapter suppliers.

In another development, Intel has turned control of its Exchangeable Card Architecture (ExCA) over to the PCMCIA. ExCA, which defines an 80x86 system implementation of the PCMCIA specification, has always been an open spec; its control by the PCMCIA, however, means that manufacturers of host-adapter ICs will now feel more compelled to adhere to it. Until now, most of those chip makers have followed ExCA but have added their own extensions.—by Gary Legg

Award Software International Inc, Los Gatos, CA, (408) 370-7979, fax (408) 370-3399. **Circle No. 518**

Systemsoft Corp, Natick, MA, (508) 651-0088, fax (508) 651-8188. **Circle No. 519**

Vadem, San Jose, CA, (408) 943-9301, fax (408) 943-9735. **Circle No. 520**

Texas Instruments, Denver, CO, (800) 477-8924, ext 3722. **Circle No. 521**

Military application finds home in baseball stadium

Declining defense budgets are causing some companies to look for new places to use their applications. Computer scientists at Georgia Tech Research Institute have adapted software originally intended for a military application to develop a traffic-control application called TERMINUS (Traffic Event Response and Management for Intelligent Navigation Utilizing Signals). The software runs on Sun SPARC and similar workstations.

The original software was a neural-network program that helped pilots spot enemy threats, such as missile systems or radar installations. In its new incarnation, the software spots traffic-flow problems, such as accidents and traffic bottlenecks. The program displays an animated color map of streets, parking lots, and traffic conditions in problem ar-

SHORTS

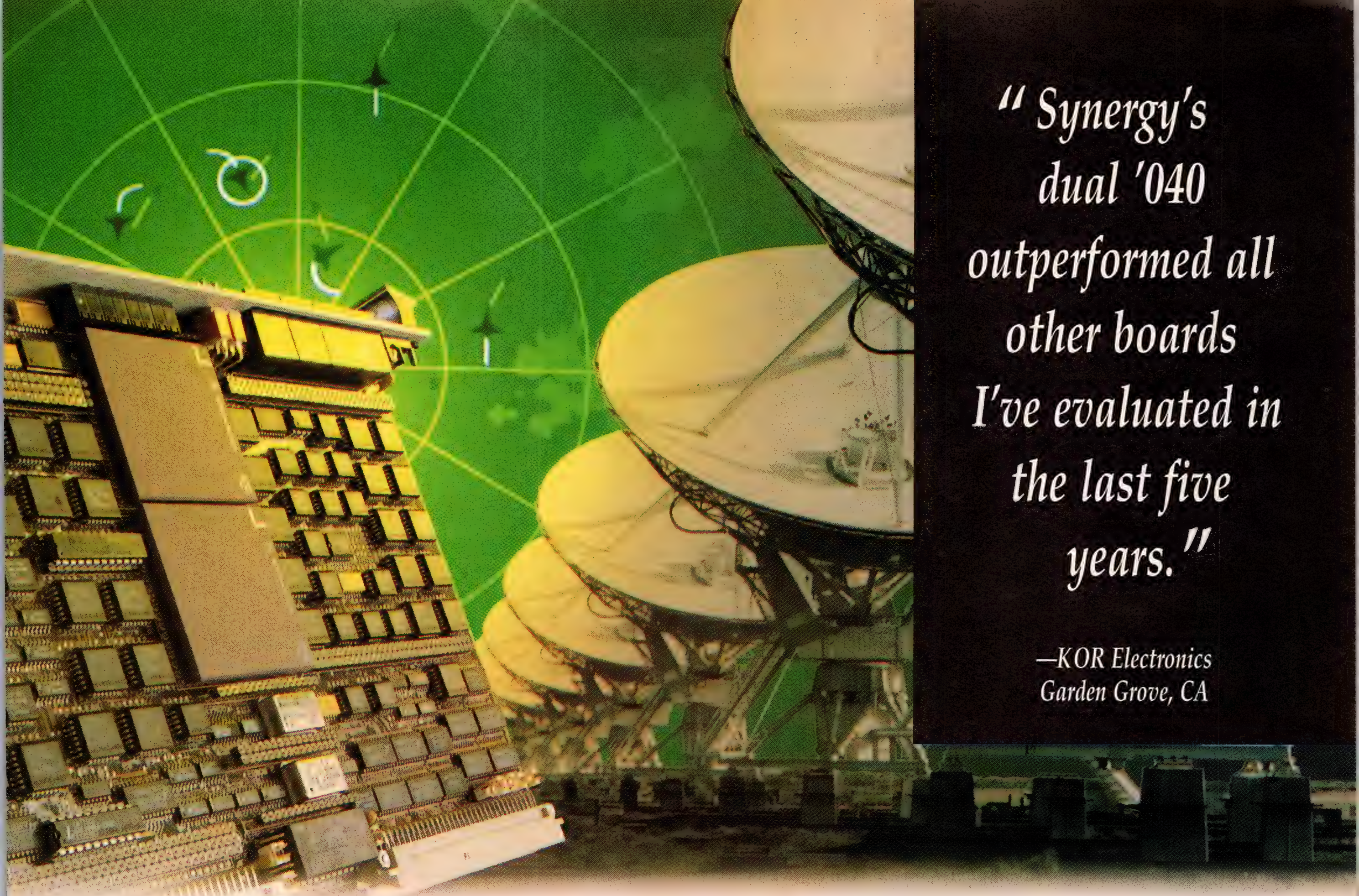
Fast 3.3V UVEPROM makes debut. WSI now offers a 2k×8-bit 3.3V UV-erasable PROM, the WS57LV291C, in 70- and 90-nsec speed grades for $6.30 and $5.40 (100), respectively. WSI Inc, Fremont, CA, (510) 656-5400, fax (510) 657-5916. **Circle No. 523**

Clock-generator IC eliminates skew. In August, Micro Linear Corp will release a $14 (1000) clock-generator IC that creates eight skewless clocks. The phase-locked-loop (PLL) device uses a second trace to sense and correct the phase error at each clock's destination.

Micro Linear Corp, San Jose, CA, (408) 433-5200. **Circle No. 524**

EDAC cosponsors DAC. EDAC (Electronic Design Automation Companies) has been given cosponsorship status for the Design Automation Conference (DAC) in Dallas, TX, on June 14 to 18.

EDAC, San Jose, CA, (408) 287-6371, fax (408) 287-7981. **Circle No. 525**



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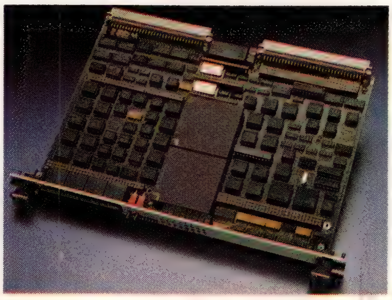

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CIRCLE NO. 18

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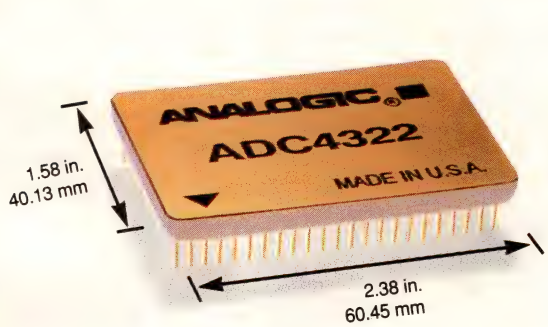

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CIRCLE NO. 113

eas. The software's initial application is to simulate traffic conditions around the Atlanta-Fulton County Stadium (home of the Atlanta Braves). The city of Atlanta will also use the system to prepare for controlling traffic during the 1996 Olympics.

—by Susan Rose

Georgia Institute of Technology, Atlanta, GA, (404) 894-3444, fax (404) 894-6983.

Circle No. 522

Migrate designs among PLDs, FPGAs

ATrans software from ACEO Technology lets you translate ASIC, PLD, and FPGA designs among different devices. The software preserves the design's original functions and timing relationships. You can reuse test vectors, simulation vectors, and design documentation because structural faults are unchanged, internal nets remain visible, and the names of instances, nets, pins, and their connections are unchanged.

The software supports Xilinx and Actel FPGAs and other FPGAs through standard netlist formats. Support for PLDs is through the Palasm and OpenAbel formats. The software runs on Sun SPARCstations and is available now. Prices start at $35,000; you can see it demonstrated at the Design Automation Conference in Dallas.

—by Doug Conner

ACEO Technology Inc, Fremont, CA, (510) 656-2189. **Circle No. 527**

Alliance unveils video-compression chips and tools

Array Microsystems and Samsung Semiconductor (San Jose, CA) have jointly developed a family of video-compression coprocessor chips that address a variety of applications. The a77 product family, called Videoflow, uses an architecture based on a collection of independent processing units with a common bus integrated into a single IC. The family will begin with two members: the image-compression coprocessor (ICC) and the motion-estimation coprocessor (MEC).

The expected performance of a system based on these two chips is real-time 30-frame/sec encoding and decoding of JPEG, MPEG 1, and P*64 images. For JPEG video, the set handles 720×480-pixel images. For MPEG 1, the set can encode 352×240-pixel SIF (standard interchange format) images, decode two simultaneous SIF images, or decode one full-screen television image. With P*64, the set can encode one and decode two CIF (common intermediate format: 352×288-pixel images) or encode one and decode seven quarter-CIF (176×144-pixel) images.

The alliance plans to have first silicon and a working demo by Fall Comdex; development tools, however, are available now. Softec Inc (Waltham, MA) has developed programming, simulation, and debugging tools for the Videoflow family. The tools take advantage of the family's partitioned architecture and let you program your compression algorithms using a data-flow diagram. Each step in the diagram corresponds to an instruction in one of the chip's processing elements, so that programmers needn't worry about data-manipulation details—the IC handles those automatically.—by Richard A Quinnell

Array Microsystems, Colorado Springs, CO, (719) 540-7999, fax (719) 540-7950. **Circle No. 526**

DSP software adds a telecom simulation library

Designers working on telecom systems using Mentor Graphics' DSP Station products now have the option of using ICUCOM Corp's (Troy, NY) Telecom Simulation Library, which adds hundreds of simulation models for digital telecom-system design. The simulation library provides fully parametrized and programmable block models. The library supports a variety of communications channels, including mobile radio, fiber optic, HF, Satcom, tropospheric scatter, wireline, Line-of-Sight, Rayleigh, Rician, and impulse noise. The simulation library is a $10,000 option to DSP Station and will be available in June.—by Doug Conner

Mentor Graphics, Wilsonville, OR, (800) 547-3000. **Circle No. 528**

MCP targets small systems

S-MOS Systems Inc is now offering multichip packaging (MCP) for low-cost, high-volume applications in small-form-factor systems. The packaging uses polyimide/glass-epoxy substrate material and incorporates surface-mount and/or chip-on-board (COB) packaging on single- or double-sided assemblies within standard quad-flatpack (QFP) designs. The combination of standard high-pin-count QFPs, COB packaging, and lead frames lets the company minimize module costs and development times.

MCP uses existing fine-pitch technologies. The process uses gold plating on interconnects to maximize COB bond quality and reliability. Initially, the company is offering 184- and 232-pin QFPs with a 0.65-mm contact pitch. To provide some pricing perspective, a 32×32×3.8-mm, 184-pin module with two chips and up to 300 interconnect bonds will cost $13 to $15 (10,000).

—by Tom Ormond

S-MOS Systems Inc, San Jose, CA, (408) 954-0120. **Circle No. 529**

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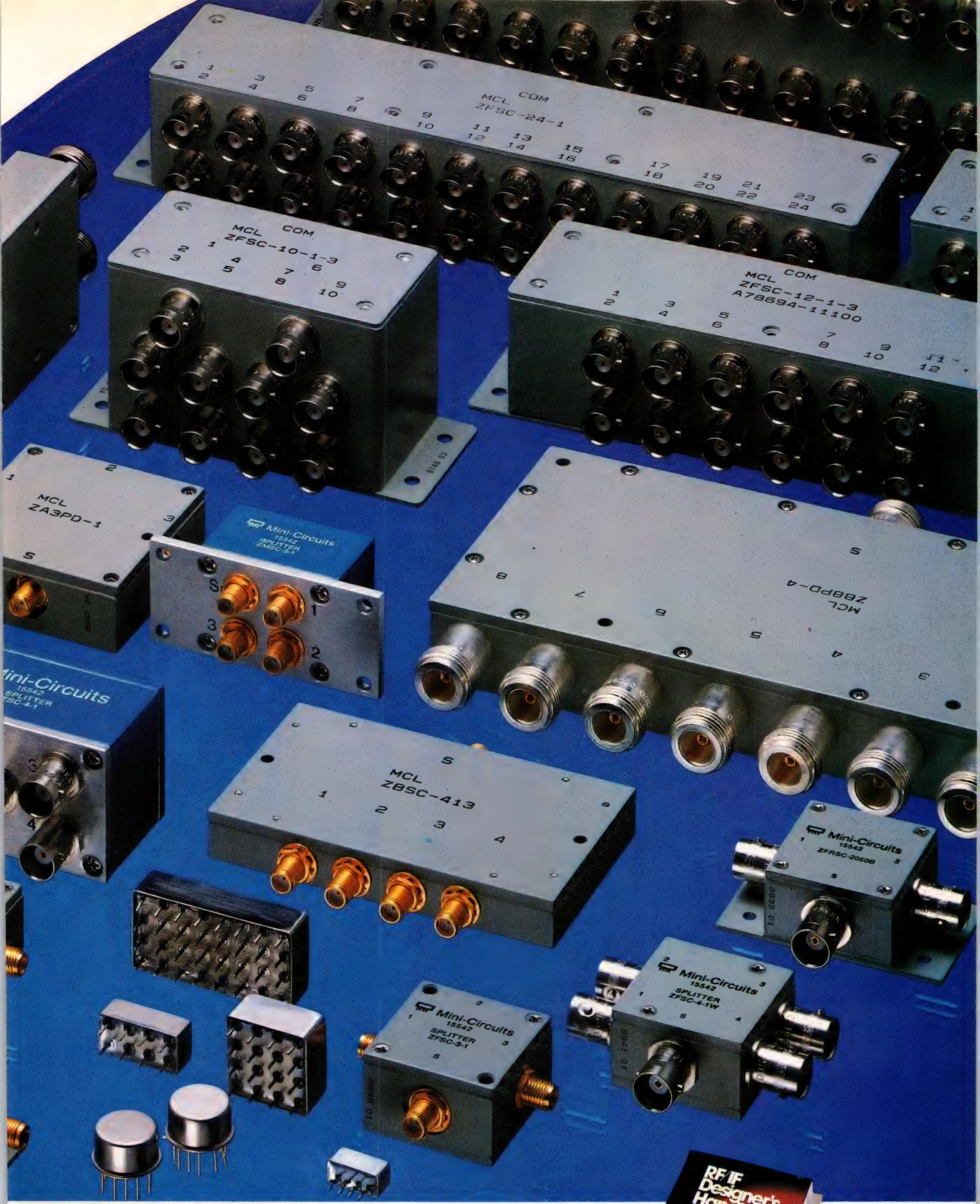

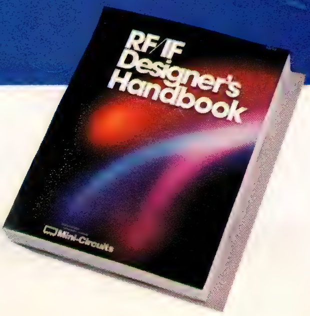

For detailed specs on all Mini-Circuits products refer to
• THOMAS REGISTER Vol. 23 • MICROWAVES PRODUCT DIRECTORY
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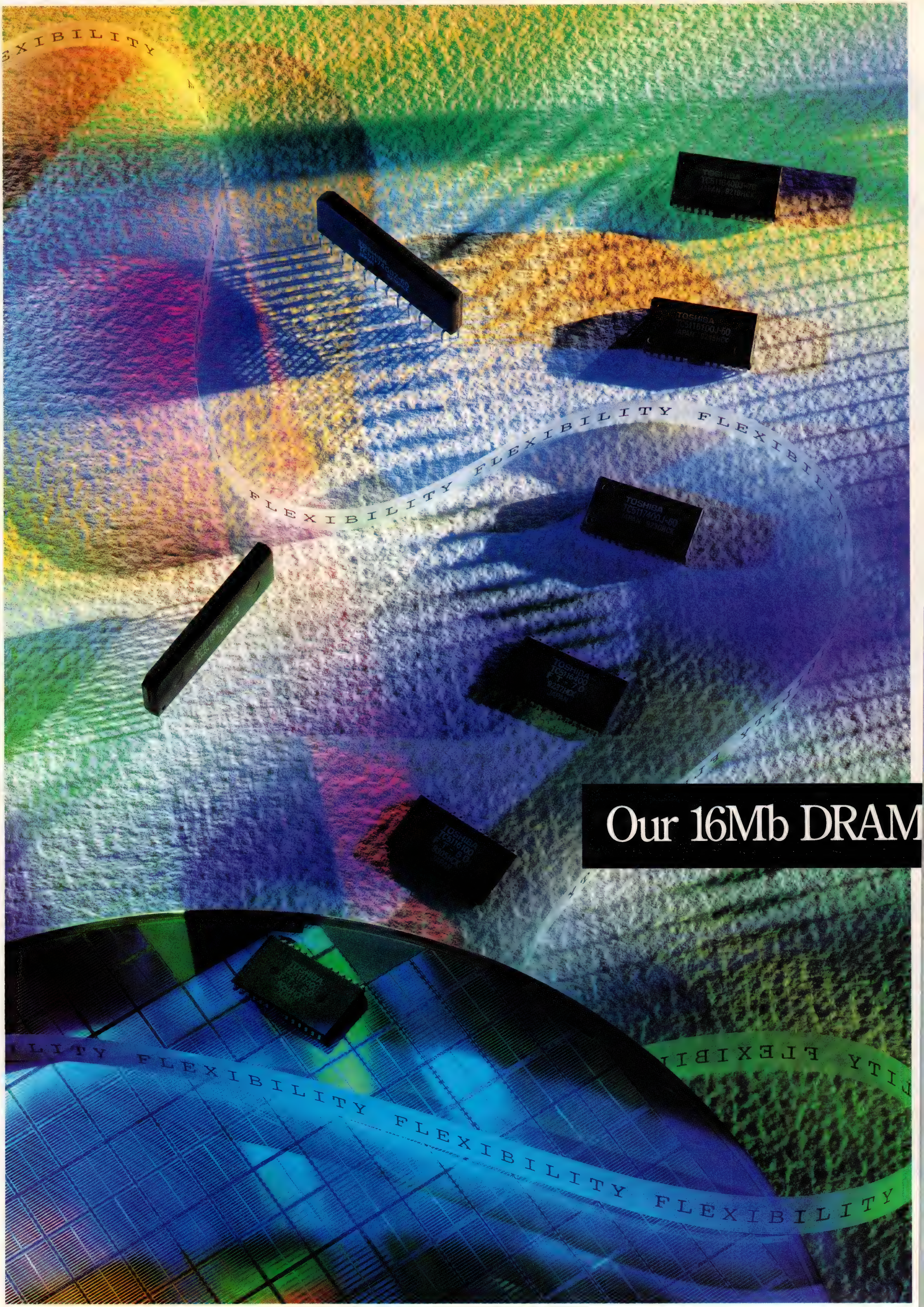
CIRCLE NO. 19

F134 Rev D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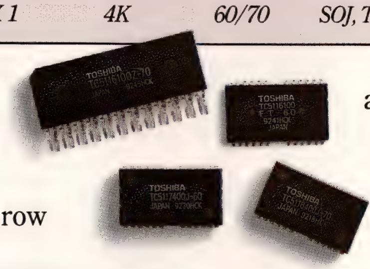
2M X 8	*2K*	*60/70/80*	*SOJ, TSOP*
4M X 4	*2K, 4K*	*60/70*	*SOJ, TSOP*
16M X 1	*4K*	*60/70*	*SOJ, TSOP*



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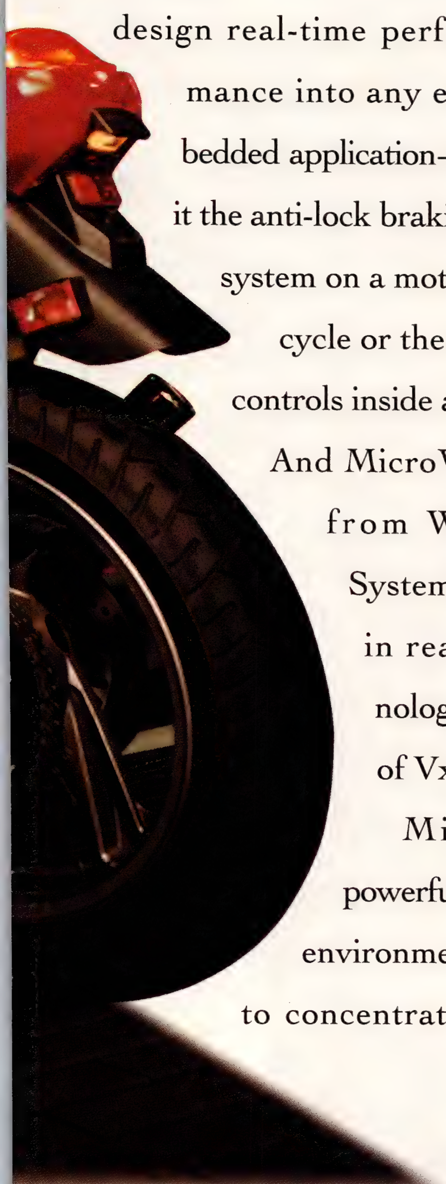

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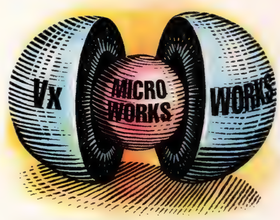

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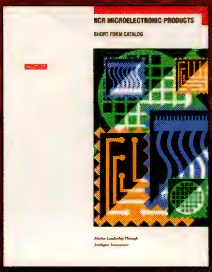

CIRCLE NO. 137

An effective engineer is a good communicator

Incompetent or unethical management is not the reason that some engineers do not receive the recognition they feel they deserve, despite Mr Pullen's assertions (Signals & Noise, February 18, 1993, pg 29).

Engineers who "quietly contribute" may be considered poor "team players," but that is their fault, not the fault of management. Quiet contributors are engineers who have failed to communicate effectively with the other people in their organization.

I suggest that the engineer who identifies with the description given by Mr Pullen ask him or herself:

- Do I inform my management of the reasons why I've made an engineering decision? Do I tell them the consequences of a different decision?
- Do I make my engineering opinion heard in matters of project scope and schedule? Do I present alternatives?
- Do I critically examine tasks assigned to me by management? Do I present management with alternatives to tasks that have definitions I disagree with?
- Do I keep my coworkers informed of my work? Do I make sure that my work fits well with what others are doing?
- Do I understand the business consequences of my engineering decisions? Do I communicate with management with that in mind?
- Do I speak out when my engineering judgment tells me that a management action is unethical, dangerous, or illegal?

Engineering is not just about creating. It is about creating useful, safe, and marketable products as a member of a team.

Effective engineers expect to communicate without being asked. Ineffective engineers expect to be asked to communicate.

Many in engineering feel that the profession does not get the recognition it deserves. That recognition will be longer in arriving if many engineers fall into the trap laid by Mr Pullen.

Brian P Gross
Hewlett-Packard Co
Rohnert Park, CA

Workstations vs PCs: The debate continues

To be sure, the thrust of Charles Small's March 18 cover story, "Workstation vs PCs" was indeed that PCs are becoming similar to workstations, but on balance, I felt he still hedged toward workstations. In light of PC developments like Windows NT, local buses, multiprocessors, (graphics and other) coprocessors, the Pentium, etc, I question whether workstations falling much short of supercomputers offer any material advantage.

Mark Davis
Dolby Labs
San Francisco, CA

I have just finished reading "Workstations vs PCs" (*EDN*, March 18, 1993, pg 164), and I must congratulate Charles Small: It is one of the most excellent examples of pure fiction that I have read lately. Unfortunately, a technical article is supposed to have some basis in fact, a minor point that Mr Small has overlooked. May I suggest that he find a new line of work outside the field of technical writing.

The PC he used as an example in the article may have been the standard a few years ago, but today the common high-end PC is more like my home system, a 66-MHz 80486 with a 1-Mbyte cache and 256 Mbytes of RAM. I have a local bus with a 32-bit video board and a fast-access hard drive. No bottlenecks here. I also use a modern DMA chip set, not one of the 8085 genre. I could go on about the relative cost to performance of hardware and software and the relative utility and friendliness of Unix vs MS-DOS, but I think you just might get the idea already. I sincerely hope EDN publishes a current and correct article soon to right this travesty of a technical article.

I use both PCs and workstations (Sun) in my duties as an aerospace design engineer, and I support most of the hardware for the other engineers in my group. I am also an "informal tech support" person for Microsoft and have responsibility for a large portion of the utility and system software for this group.

Steve Bushore
Space Systems
Palo Alto, CA

Going metric will help the US compete globally

I enjoyed the editorial "Let's go metric" (*EDN*, March 31, 1993, pg 23). You are absolutely right. I may be biased. I grew up with the metric system. When I came to America in 1953 I was immersed in the English language and the English units. It took me about five weeks to get used to both. Total immersion does work.

We have so many professions that are exclusively metric already. Almost all of our engineering fields (with the exception of architecture, the building trades, and many of our machine shops) are hanging on to the old English units. Our chemists, doctors, nurses, pharmacologists, and others have all been trained and are using the metric system. The cost of replacing old "English unit" machine tools is high. But our automobile industry and its suppliers have made the change to be competitive in the world market. Those that refuse to change will be left behind and end up standing in the unemployment lines.

Text continued on pg 30

It's easy to reason with a logical mind. It's impossible to reason with politicians. Maybe we need a grassroots write-in campaign to show President Clinton, and others in Washington, why Americans are losing in the world market.
Fred Wiechering
Comtel Midwest Co
Arlington Heights, IL

The sky's the limit

Every time I see an EDN editorial, I tell myself I'll just read a line or two to see what it's about. I always read it completely and feel an urge to write back to let you know how I feel. It always stimulates me to reflect on the human dimension of engineering.

Without being an American, I felt that the Steve Leibson's editorial, "Reclaiming our vision" is addressed to me, too (EDN, March 18, pg 41). I witnessed the first lunar mission as an 11-year-old boy in an eastern-block country. It changed my life. It motivated me through all these years as an engineer, a researcher, and an owner of a company. It's great to know that somebody on the other side of the world feels the way you do. I feel the "black and white behemoth" lying broken on some shore that made you cry is still an inspiration for many of us.
Ovidiu Basta
AERA GmbH
Wiesloch, Germany

The editorial, "Reclaiming our vision" struck home. My dad was an early space pioneer, and my first job was Apollo-related.

We've accomplished great things in space. Can you imagine that the LM's computer was transistorized (no ICs)? Yet each mission was a success. Even the ill-fated Apollo 13 showed that the technology worked; that a quarter of a million miles from each other, the backups could save three lives.

Now we seem directionless. The Atlas failure, the third in a handful of launches, will no doubt reinforce Aireanne's success. The Shuttle just has not lived up to its workhorse billing.

I'm a great believer in adventures, but even I cannot see a good reason to go to Mars at this point. The cost is so extreme; the benefits so murky. For space to be a long-range endeavor, we need to find commercial successes there.

There are some bright prospects. The Pegasus vehicle, launched from a B52, can put a small payload into low earth orbit fairly cheaply. Mass production would reduce these costs even more. All sorts of proposals are out now for large satellite systems for personal communications. Perhaps the government should be encouraging investment in these less-dramatic but more rewarding technologies.

We will certainly lose our way if we don't start focusing on result-oriented space development, on profits over long-term exploration. Normally I'm a great believer in long-range programs, but the nation is simply too broke to carry on as it has since the '50s.
Jack G Ganssle,
President
Softaid Inc
Columbia, MD

I read Steve Leibson's March 18 editorial with interest. I, too, share his vision of reclaiming our past greatness. His, however, is (pardon the pun) pie-in-the-sky, whereas mine is based on more earthly things.

I would love to see our consumer products be manufactured in this country again and reclaim the markets we once had. I would love to see Detroit get its act together instead of constantly telling us that it is only a perception that the Japanese cars are better. I would love to see our industry leaders adapt long-range, visionary thinking for long-term benefits, instead of worrying about the next quarter's bottom line. To have excellent public transportation with buses and trains to get commuters out of their cars is a much greater and worthwhile achievement than space probes or shuttles.

In brief, it is only when we produce for a global market, by again becoming the industrial giant we once were, that we should begin to think about a costly space program. With very limited budgets we must do projects in order of importance.

Mars has been up there a long time, and it will still be there when we can afford to explore it. We must solve our earthly problems first—that's what I would ask President Clinton to strive for.
Eric Neugroschel
Metuchen, NJ

Equation corrections

In the March 18 issue of EDN, two equations appeared incorrectly in the article "Take advantage of current-feedback amps for high-frequency gain."

On pg 217, the precise expression for the actual closed-loop gain should read

$$A_{CL} = V_{OUT}/V_{IN} = A_I/(1 + (R_F + A_I R_B)/R_{OL}).$$

On pg 219, the precise expression for the actual feedback gain (A_F) should be

$$A_F = A_I/(1 + (R_F + (A_I + 1)R_B)/R_{OL}).$$

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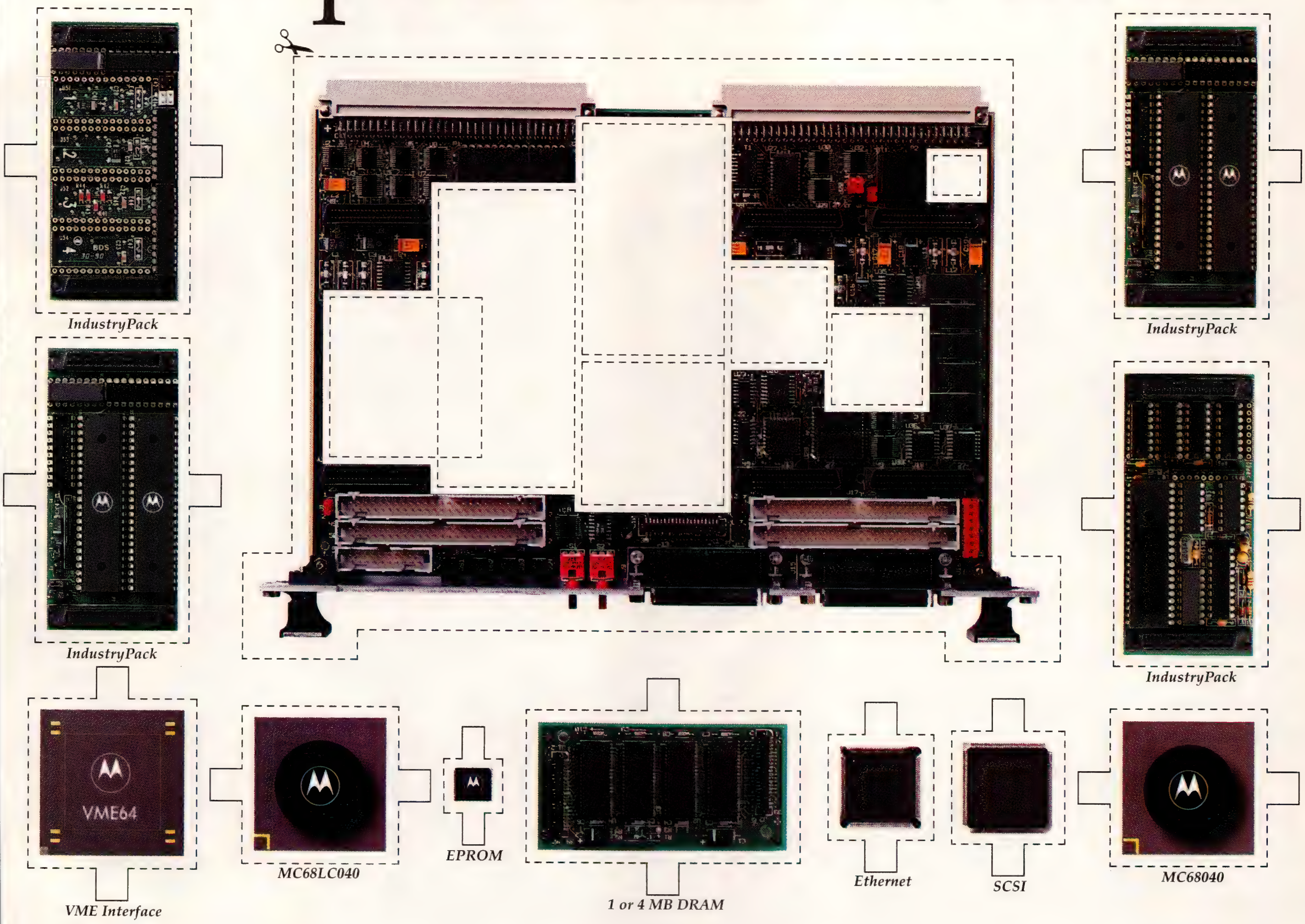

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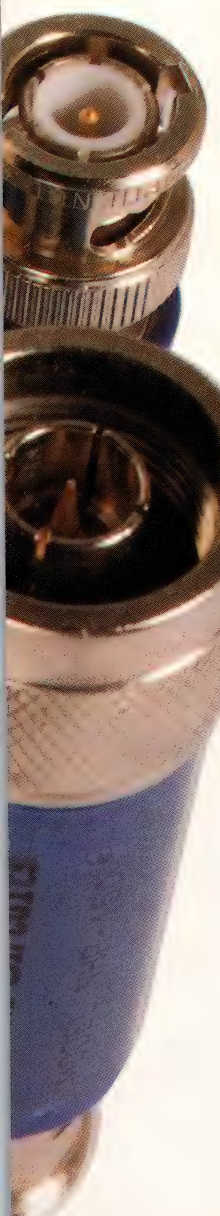
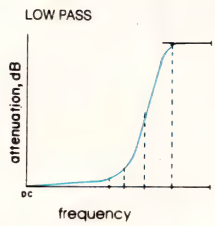




low pass, Plug-in, dc to 1200MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
★LP-5	DC-5	8-10	10-200
★LP-10.7	DC-11	19-24	24-200
★LP-21.4	DC-22	32-41	41-200
★LP-30	DC-32	47-61	61-200
★LP-50	DC-48	70-90	90-200
★LP-70	DC-60	90-117	117-300
★P-90	DC-81	121-137	167-400
★LP-100	DC-98	146-189	189-400
★LP-150	DC-140	210-300	300-600
★LP-200	DC-190	290-390	390-800

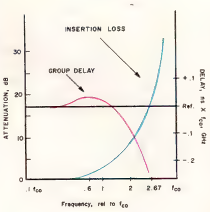
Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
★LP-250	DC-225	320-400	400-1200
★LP-300	DC-270	410-550	550-1200
★LP-450	DC-400	580-750	750-1800
★LP-550	DC-520	750-920	920-2000
★LP-600	DC-680	840-1120	1120-2000
★LP-750	DC-700	1000-1300	1300-2000
★LP-800	DC-720	1080-1400	1400-2000
★LP-850	DC-760	1100-1400	1400-2000
★LP-1000	DC-900	1340-1750	1750-2000
★LP-1200	DC-1000	1620-2100	2100-2500

Price, (1-9 qty), all models: plug-in $14.95, BNC $32.95, SMA $34.95, Type N $35.95

Surface-mount, dc to 570MHz

SCLF-21.4	DC-22	32-41	41-200
SCLF-30	DC-30	47-61	61-200
SCLF-45	DC-45	70-90	90-200
SCLF-135	DC-135	210-300	300-600
SCLF-190	DC-190	290-390	390-800
SCLF-380	DC-380	580-750	750-1800
SCLF-420	DC-420	750-920	920-2000

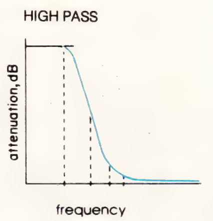
Price, (1-9 qty), all models: $11.45



Flat Time Delay, dc to 1870MHz

Model No.	Passband MHz loss < 1.2dB	Stopband MHz loss > 10dB	Stopband MHz loss > 20dB	VSWR Freq. Range, DC thru 0.2fco X̄	VSWR Freq. Range, DC thru 0.6fco X̄	Group Delay Variations, ns Freq. Range, DC thru fco X̄	2fco X̄	2.67fco X̄
★BLP-39	DC-23	78-117	117	1.3:1	2.3:1	0.7	4.0	5.0
★BLP-117	DC-65	234-312	312	1.3:1	2.4:1	0.35	1.4	1.9
★BLP-156	DC-94	312-416	416	0.3:1	1.1:1	0.3	1.1	1.5
★BLP-200	DC-120	400-534	534	1.6:1	1.9:1	0.4	1.3	1.6
★BLP-300	DC-180	600-801	801	1.25:1	2.2:1	0.2	0.6	0.8
★BLP-467	DC-280	934-1246	1246	1.25:1	2.2:1	0.15	0.4	0.55
▲BLP-933	DC-560	1866-2490	2490	1.3:1	2.2:1	0.09	0.2	0.28
▲BLP-1870	DC-850	3740-6000	5000	1.45:1	2.9:1	0.05	0.1	0.15

Price, (1-9 qty), all models: plug-in $19.95, BNC $36.95, SMA $38.95, Type N $39.95
NOTE: ▲: -933 and -1870 only with connectors, at additional $2 above other connector models.

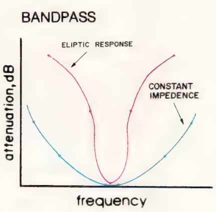


high pass, Plug-in, 27.5 to 2200MHz

Model No.	Stopband MHz loss < 40dB	Stopband MHz loss < 20dB	Passband, MHz loss < 1dB	VSWR Passband Typ.
★HP-25	DC-13	13-19	27.5-200	1.8:1
★HP-50	DC-20	20-26	41-200	1.5:1
★HP-100	DC-40	40-55	90-400	1.8:1
★HP-150	DC-70	70-95	133-600	1.8:1
★HP-175	DC-70	70-105	160-800	1.5:1
★HP-200	DC-90	90-116	185-800	1.6:1
★HP-250	DC-100	100-150	225-1200	1.3:1
★HP-300	DC-145	145-170	290-1200	1.7:1

Model No.	Stopband MHz loss < 40dB	Stopband MHz loss < 20dB	Passband, MHz loss < 1dB	VSWR Passband Typ.
★HP-400	DC-210	210-290	395-1600	1.7:1
★HP-500	DC-280	280-365	500-1600	1.8:1
★HP-600	DC-350	350-440	600-1600	2.0:1
★HP-700	DC-400	400-520	700-1800	1.6:1
★HP-800	DC-445	445-570	780-2000	2.1:1
★HP-900	DC-520	520-660	910-2100	1.8:1
★HP-1000	DC-550	550-720	1000-2200	1.9:1

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95



bandpass, Elliptic Response, 10.7 to 70MHz

Model No.	Center Freq. (MHz)	Passband I.L. 1.5 dB Max. (MHz)	3 dB Bandwidth Typ. (MHz)	Stopbands I.L. > 20dB at MHz	Stopbands I.L. > 35dB at MHz
★BP-10.7	10.7	9.6-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000
★BP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000
★BP-30	30.0	27.0-33.0	25-35	22 & 40	3.2 & 99-1000
★BP-60	60.0	55.0-67.0	49.5-70.5	44 & 79	4.6 & 190-1000
★BP-70	70.0	63.0-77.0	68.0-82.0	51 & 94	6.0 & 193-1000

Price, (1-9 qty), all models: plug-in $18.95, BNC $40.95, SMA $42.95, Type N $43.95

Constant Impedance, 21.4 to 70MHz

Model No.	Center Freq. MHz	Passband MHz loss < 1dB	Stopband loss > 20dB at MHz	VSWR 1.3:1 Total Band MHz
★IF-21.4	21.4	18-25	1.3 & 150	DC-220
★IF-30	30	25-35	1.9 & 210	DC-330
★IF-40	42	35-49	2.6 & 300	DC-400
★IF-50	50	41-58	3.1 & 350	DC-440
★IF-60	60	50-70	3.8 & 400	DC-500
★IF-70	70	58-82	4.4 & 490	DC-550

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95

NOTE: ★**Add Prefix P, B, N, or S for Pin, BNC, N, or SMA connector requirement.**

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EDITED BY JULIE ANNE SCHOFIELD

Spice user gets right result with wrong netlist

Recently, I simulated a simple circuit using a professional version of Spice (MicroSim's PSpice) running on a 386-based PC. The circuit consisted of three op amps, one of which was an adder with two inputs set at unity dc gain. The results I got puzzled me and raised doubts in my mind about Spice's validity.

I made a mistake while typing in the circuit file and ended up reversing the inputs of the adder op amp. The resulting circuit had the op amp's inverting input connected to ground (either directly or through a resistor) and the feedback resistor tied to the noninverting input. I did not catch this mistake because Spice gave me the result I was looking for. When I did catch and correct the mistake, the simulation result was exactly the same. I then tried a series of tests by typing in a new circuit file with only the adder subcircuit and simulating it using different op-amp models (such as the LM324 and OP97) set at gains higher than 1. In any case, Spice was not able to distinguish between the correct adder (negative feedback) and the incorrect adder (positive feedback) and gave me identical results for both. I even tried Berkeley Spice2G.6 with no improvement whatsoever.

Regardless of some claims made about Spice, I always breadboard my circuits. I use Spice primarily to confirm my calculations and for fine tuning. Please shed some light on this subject for my own sake and/or point out to me what I did wrong.

Bob Pham
Lockheed Missiles & Space Co Inc
EVA Systems
Houston, TX

Larry Meares, president of Intusoft (San Pedro, CA), replies:

The problem you have encountered is one of proper circuit initialization. Under the conditions that were set up in your simulation (V1=0.1V; V2=0V; power supplies ON; .TRAN .1S 5S), Spice gives the correct answer. Let's see why.

Using the slightly simplified case of the inverting amplifier with gain A in Fig 1, we can solve the KCL equations as follows:

$$i_{out} + i_{in} = 0$$

$$\frac{V_{OUT} - \frac{V_{OUT}}{A}}{R_F} + \frac{V_{IN} - \frac{V_{OUT}}{A}}{R_I}$$

$$V_{OUT}R_I\left(1-\frac{1}{A}\right) + V_{IN}R_F - \frac{V_{OUT}}{A}R_F = 0$$

$$V_{OUT} = \frac{-V_{IN}R_F}{R_I\left(1-\frac{1}{A}\right) - \frac{R_F}{A}}.$$

$$\text{As } |A| \to \infty,\ V_{OUT} = \frac{V_{IN}R_F}{R_I}.$$

Spice is designed to solve these equations just as you would by hand. Clearly, another solution exists in which the output goes to positive infinity for linear models or the positive op-amp rail for nonlinear models. To get to this solution, the simulation can't be started under the assumption that power and signals are already present. When we make this assumption, Spice is free to create a negative initial condition at the output. This could never occur in reality because the summing-junction input is always positive. To get Spice to model the actual circuit, you must apply power and signals as a function of time, beginning with the device turned off, so that all internal nodes are initialized to zero.

Moreover, you must model the circuit like a real op amp in that it should have

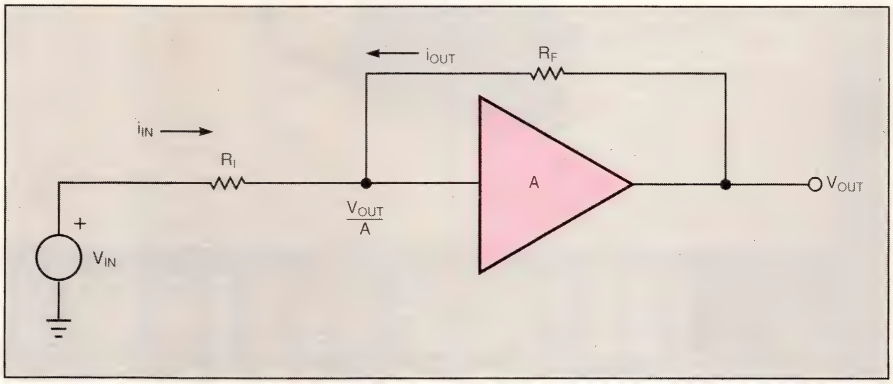

Fig 1—This simplified inverting-amplifier circuit generates the KCL equations.

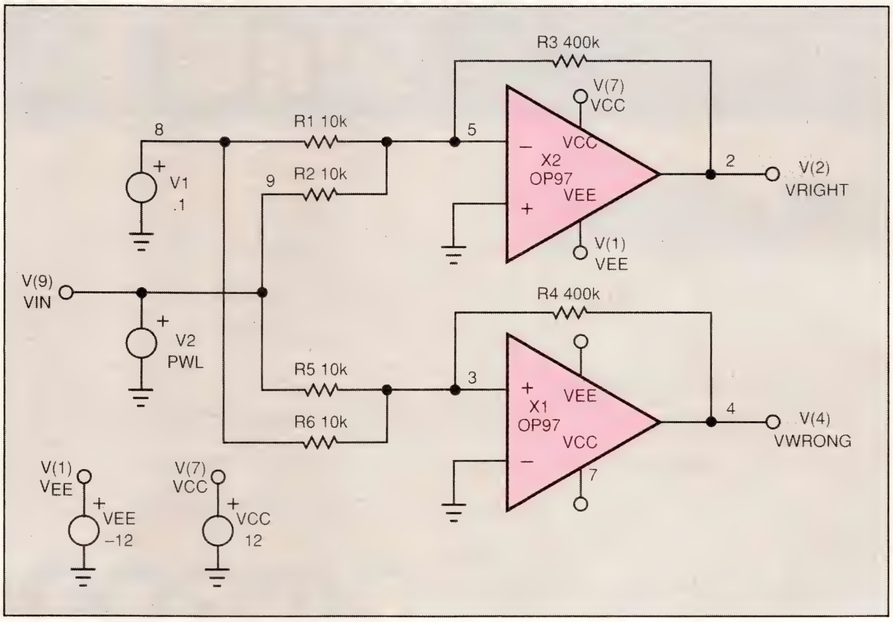

Fig 2—The reader's Spice circuit, with a modified set of initial conditions, produced the waveforms in Fig 3.

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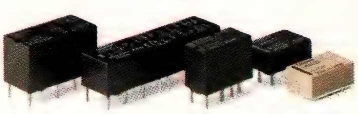

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a sense of temporal ordering; that is, the input must occur before the output. This ordering requires that there be at least one pole in the transfer function and that the time steps in the simulation be small enough to "expose" the pole. The pole will lower the op-amp gain for small time steps so that an output solution cannot be found for negative outputs.

To shorten the Spice time steps, change .TRAN from ".1S 5S" to ".1MS 5MS". To ramp the power supplies, change "V+ 10 0 12V 0 .1M" to "V+ 10 0 PULSE 0 12 0 .1M". It is best to give the power-supply ramp a realistic ramp time, in this case 0.1 msec. **Fig 2** and **Fig 3** show the simulation results. The version of Spice we used was IsSpice3, a 32-bit version of Spice based on the latest Berkeley Spice 3E.2 revision.

This method may seem pretty complex for a novice Spice user; however, it's a standard technique when the initial operating point is suspect. You point out that you use Spice to confirm and quantify results you expect. I strongly recommend that Spice users have a general idea of the circuit behavior they expect. Simple errors in constructing a Spice input could give wildly erroneous data. Intusoft offers a schematic-entry program called SpiceNet, so that mistakes like yours, made by directly entering netlists, can be avoided. At least when Spice netlists are constructed improperly, you don't get parts flying off a smoldering breadboard. Instead of ducking, you may feel like throwing the computer out the window.

But users must be prepared to debug a Spice simulation, just as they must debug a breadboard. It turns out that the steps in making a simulation run aren't that different from getting a breadboard to work: Take a series of small careful steps, and check each section of circuitry before connecting the next. Techniques specifically geared toward the simulation system are regularly discussed in our free, bimonthly Intusoft Newsletter (phone (310) 833-0710; fax (310) 833-9658). Also, you can obtain an application note on solving Spice convergence problems on the Compuserve CAD/CAE/CAM forum (GO CADDVEN for Compuserve users).

Ask EDN solves nagging design problems and provides the answers to difficult questions. Address your letters to Ask EDN, 275 Washington St, Newton, MA 02158. Fax (617) 558-4470; MCI: EDNPRIME. Or, send us a letter on EDN's bulletin-board system at (617) 558-4241, 300/1200/2400 8,N,1. From the Main System Menu, enter ss/ask_edn and select W to write us a letter.

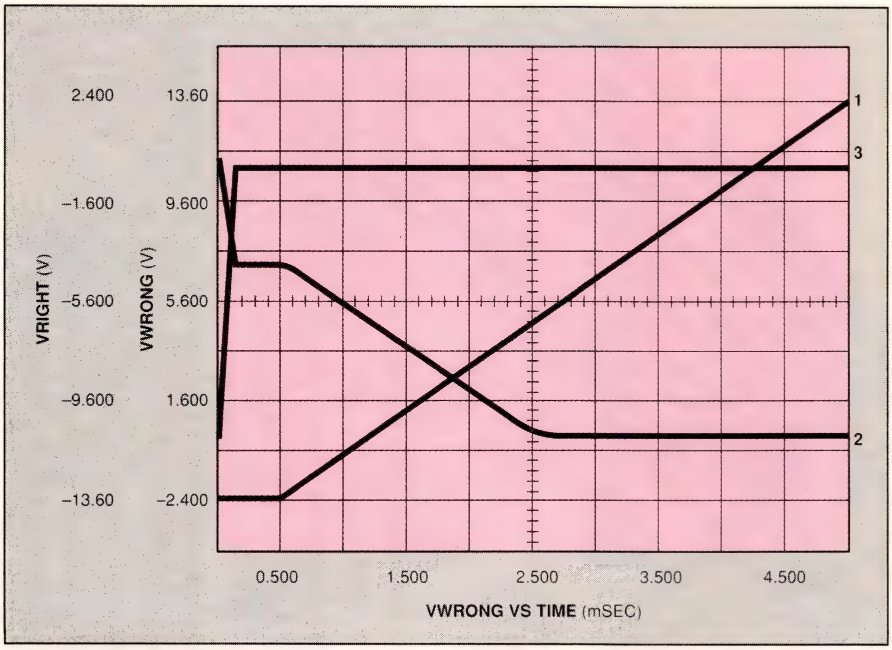

Fig 3—Simulation results show VRIGHT (waveform 2), VWRONG (waveform 3), and the input to the adder circuit (waveform 1). The VWRONG signal correctly goes into saturation when the simulation is started by ramping the power supplies.

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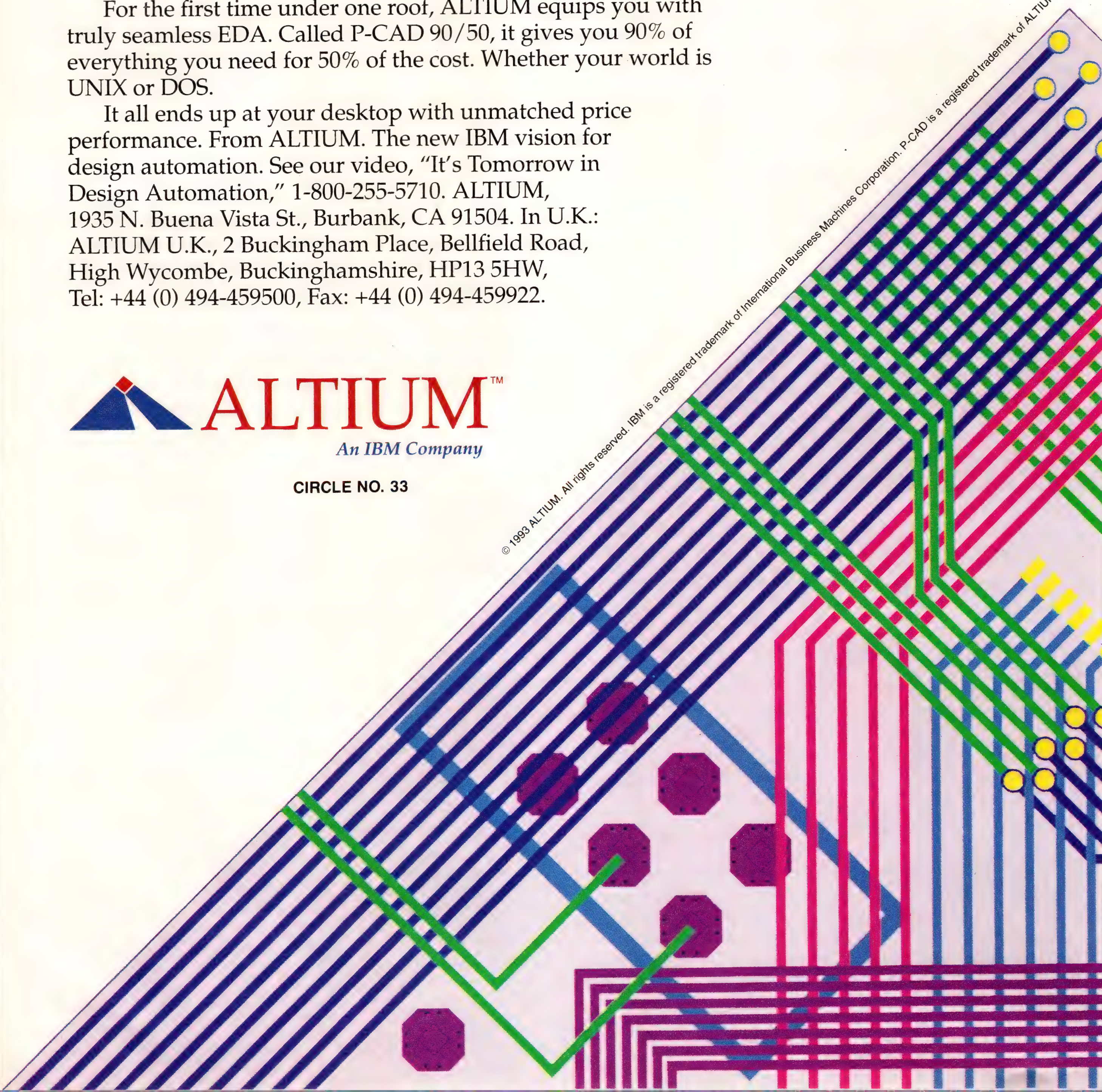

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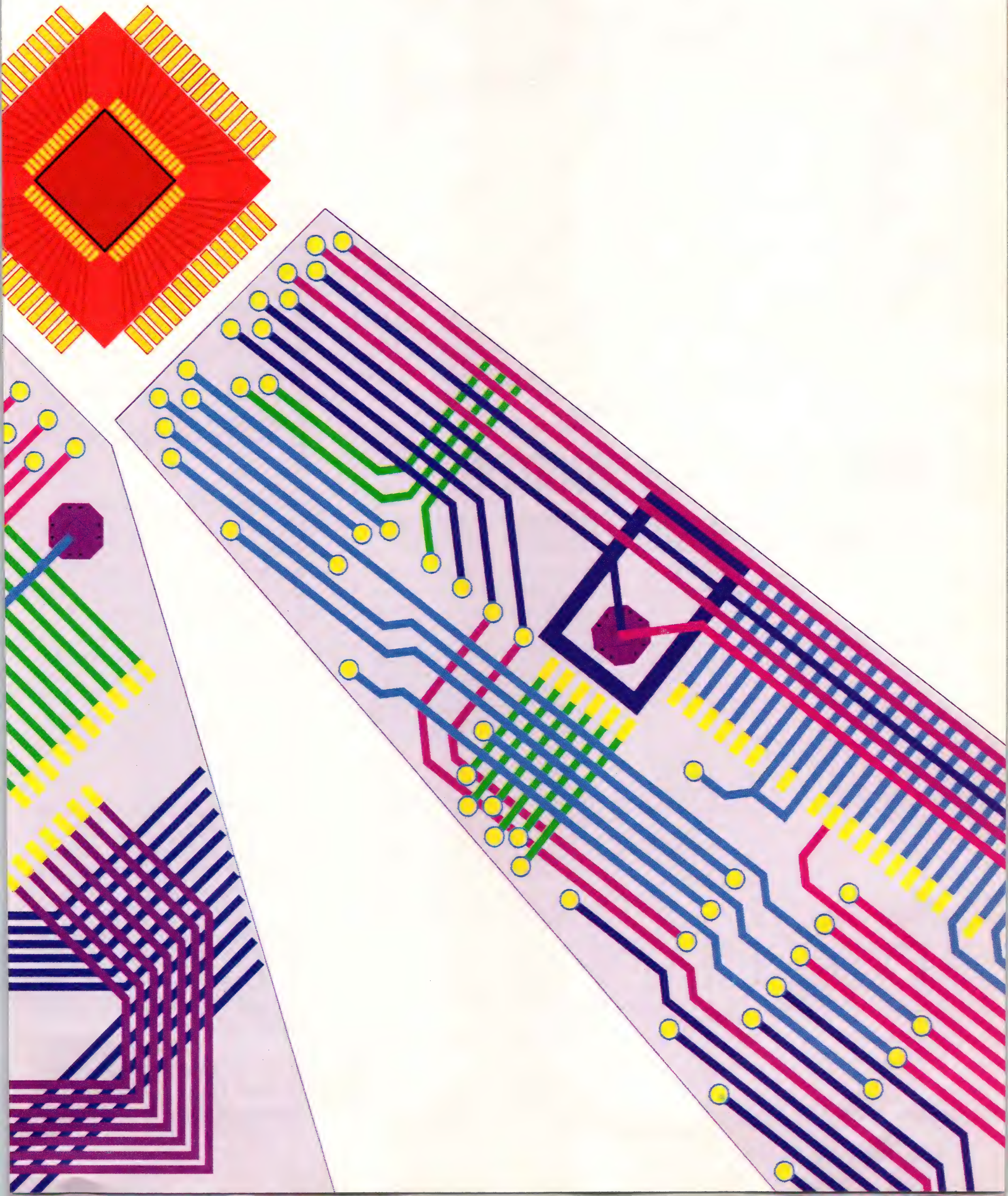

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International Microwave Symposium and Exhibition, Atlanta, GA. LRW Associates, Arnold, MD. Fax (410) 647-5136. June 14 to 18.

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Applied High-Frequency Design Techniques I (short course), Burlington, MA. Hewlett-Packard Co, Santa Rosa, CA. Phone (800) 472-5277; (707) 577-1400; in Canada, (800) 387-3154. June 21 to 25.

Usenix Association Technical Conference, Cincinnati, OH. Usenix Conference Office, El Toro, CA. Phone (714) 588-8649. June 21 to 25.

Software Development 93, London, UK. Lynne Davey, London, UK. Phone (081) 742-2828. Fax (081) 747-3856. June 22 to 24.

International Symposium on Software Testing and Analysis, Boston, MA. John Gannon, University of Maryland. Phone (301) 405-2671. June 28 to 30.

PC Expo, New York, NY. National Blenheim Expos Inc, Fort Lee, NJ. Phone (800) 829-3976. Fax (201) 346-1602. June 29 to July 1.

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DATA I/O

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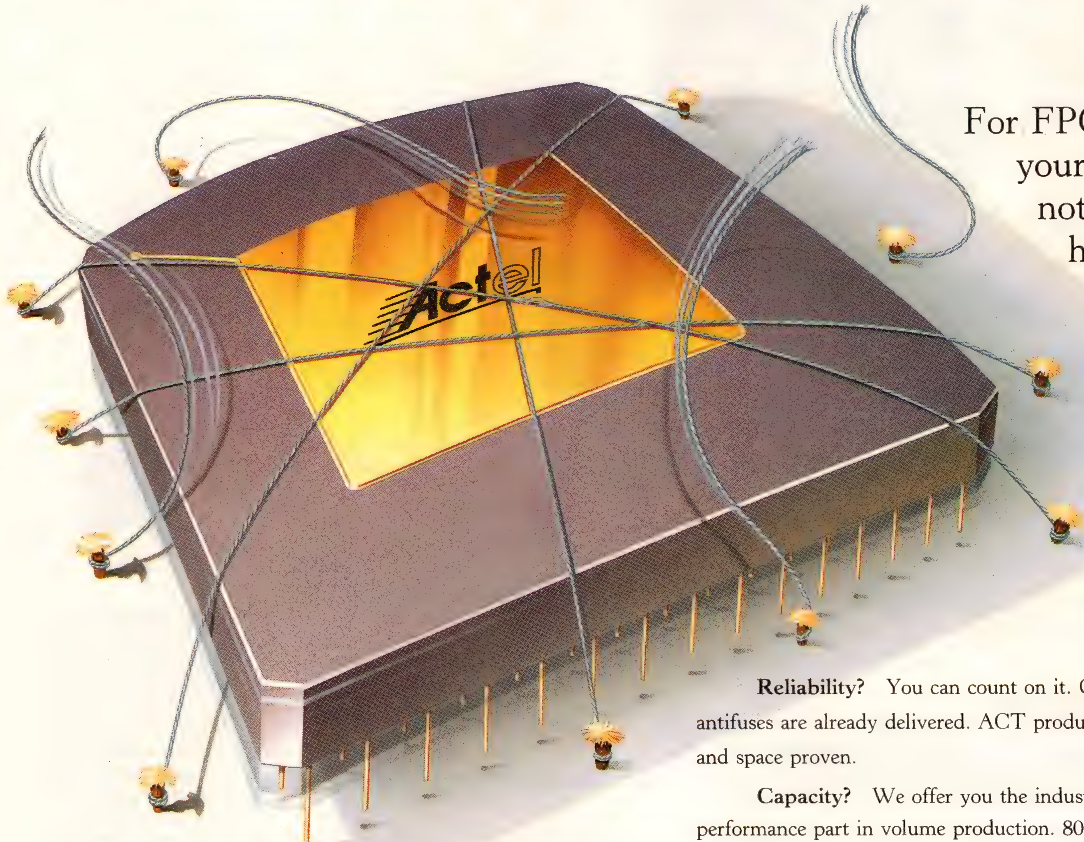

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CIRCLE NO. 110

Help us; help yourself

I'd like to be smart enough to know everything—or at least know *about* everything—that goes on in electronics. But with today's explosion of information and the plethora of information sources, no one can keep up with everything. That's why I could use some of your expertise. In a month or so, Steve Leibson, our new chief editor, our technical editors, and I will start our long-range planning for 1994. It's hard to believe that 1994 is coming so quickly, but for those of us in the publishing business, it will be here very soon.

Our planning involves assessing and predicting the products, technologies, and application information that you'll need in the year ahead. The editors and I have some good ideas and topics for '94. However, I wish I could talk with all of our readers about their concerns and what each one of you thinks we should cover in EDN. So, I'd like you to take a few minutes and drop me a note about what you think are the important topics—technologies, products, hands-on projects, and so on—that we should look at for the coming year. We're here to serve you and to give you the information you need to do a good engineering and design job. If you could put together a wish list of topics for us to cover, what would they be? Would you want more articles on neural networks, more hands-on tutorials on microprocessor design, or more articles on analog design from industry experts. Tell us; we're listening.

Much of our planning involves things you've already told us. Whenever you use our postcards to circle an Article Interest Quotient number at the end of an article, we find out which articles you like, and which you don't. We also know what products you want more information about, and which Design Ideas you like best. In addition, all of our editorial people read the comments you've written on the reader-service postcards you send. We also read what you put on our BBS and what you send in for the Ask EDN column. We also read the comments you jot down on surveys we send out. Without realizing it, you already give us a lot of information that helps us plan ahead.

In addition, we talk with manufacturers and suppliers and find out what their customers are asking about. One of my favorite questions for a vendor is, "What are the toughest design problems your customers face?" We're sometimes surprised by what we hear, but we get good information that leads to article ideas.

So, let us know what you think. Write, phone, fax, or use our computer bulletin-board system (BBS); we'd like to hear from you.

More embedded systems

Over the years, we've been covering embedded systems from microprocessor chips to complete systems, and from small real-time operating-system kernels to embedded DOS. The embedded-systems design area is so important that we're giving David Shear his own section to cover technologies, techniques, and products. In this new section you'll find development tools, single-board (nonbus) computers, and embedded software.

David's no stranger to embedded systems. Up until he rejoined EDN last fall, he was designing, developing, implementing, troubleshooting, and delivering embedded-computers for a broad spectrum of uses. If you're involved in embedded systems, watch for David's column and product section. If you want to get in touch with David, he's available by phone at (503) 754-9310, by MCI mail at EDNSHEAR, or via Internet at EDNSHEAR@MCIMAIL.COM.

Jon Titus
Editorial Director

Send me your comments via fax at (617) 558-4470, or on the EDN Bulletin Board System at (617) 558-4241, 300/1200/2400 8,N,1. From the Main System Menu, enter ss/soapbox and select W to write us a letter.

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1990 Certificate, Best Series
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1977, 1976, 1975

American Society of
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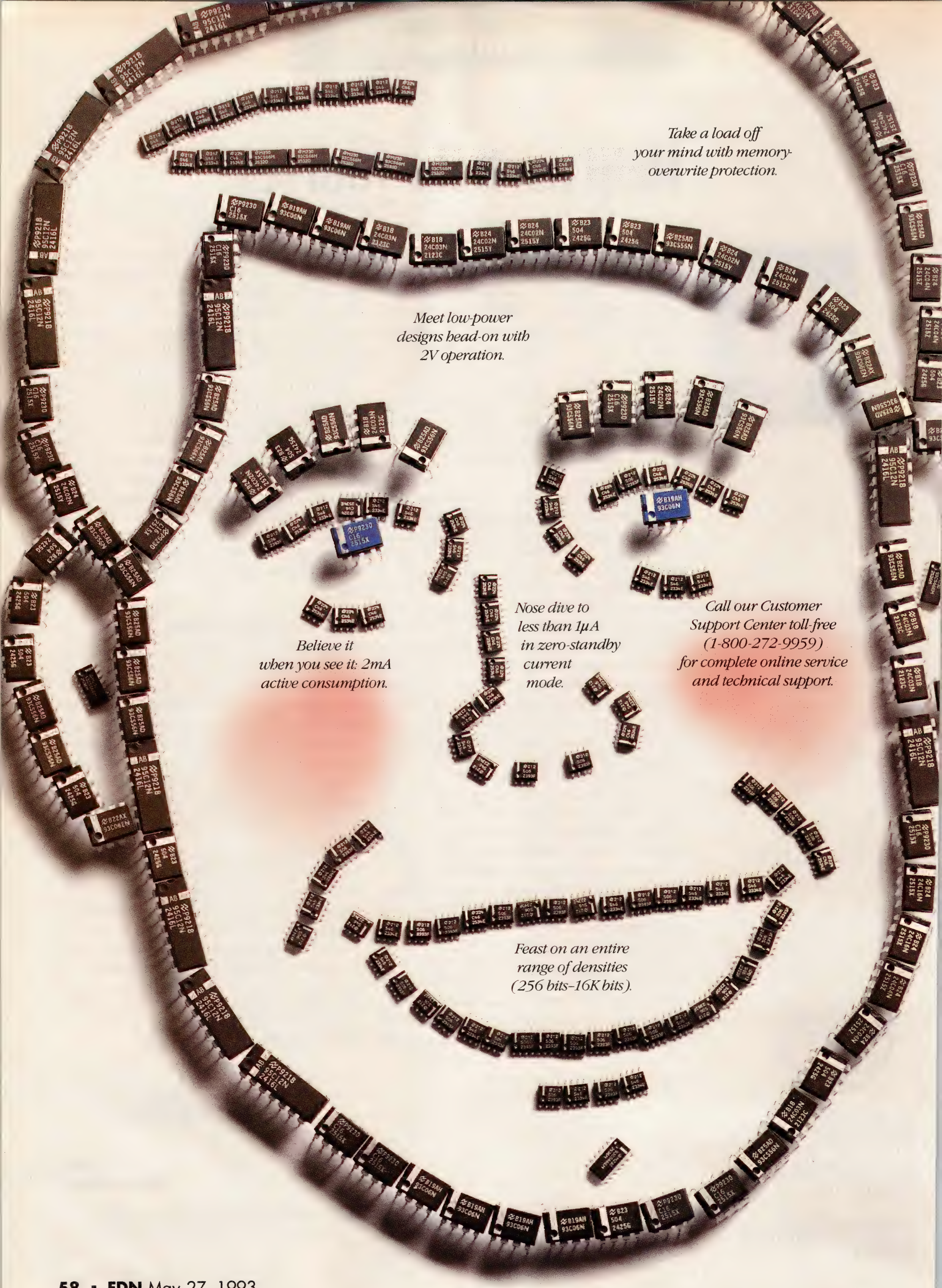
1988, 1983, 1981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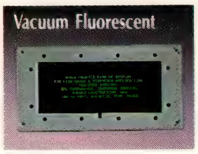

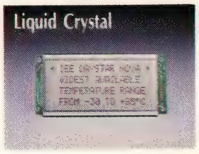

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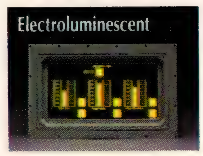

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Close data-sheet scrutiny ferrets out true performance specs

ANNE WATSON SWAGER, Technical Editor

Most analog-component data sheets contain the information you need if you know where to look and what to look out for.

Scrutinizing data sheets is an important first step in selecting analog components. Although you will eventually want to test various samples in your circuit, the data sheet tells you the performance guarantees and extremes of operation. Ultimately, the data sheet is the real contract between you and the manufacturer.

Unfortunately, a data sheet is not just a contract, but also an advertisement. Manufacturers write data sheets to show off how well their parts perform given a specific set of test methods, conditions, and specification definitions. Data sheets can sometimes make wild claims of *typical* performance and showcase exotic application circuits. At the same time, the data sheet can obscure—either intentionally or inadvertently—certain performance or application aspects of the part.

Thus, the old axiom "buyer beware" still applies. You must be rigorous when picking apart data sheets. Look for the inconsistencies and question the manufacturer about them. Just because you're familiar with a particular company and its products doesn't mean you shouldn't closely examine all the data sheets it prints. Even within a company, data sheets can vary depending on the author.

Single out specifications

Manufacturers of op amps and data converters are providing more information than ever before about the performance of their ICs. The typical op-amp or data-converter data sheet is pages long and contains tables, curves, and application notes.

All this information is both good and bad. The good part is that you have a better chance to match some of the data sheet's test conditions with your operat-

Bob Doucet

ing ones. Also, data sheets' application notes can help you do a better job of using the part. Application engineers say they field many questions that the data sheet already answers.

The negative side to all this information is that some vendors claim it actually obscures certain facts and that some lengthy data sheets simply print redundant information, or worse, leave out crucial information. A data sheet may go into much detail about a part's internal architecture but not say anything about how to actually use it. Don't let a lengthy data sheet lull you into complacency.

Seek real performance clues

A good data sheet doesn't tell you just about a part's performance—it tells you what you have to do to achieve the specified performance. It's not always obvious, though, how easy or difficult the part is to use. Search for any clues—such as temperature performance or interface requirements—the manufacturer provides in the fine print or application section.

One way to pick your way quickly and efficiently through a data sheet is to look at it as having four distinct parts: the first page, the electrical tables, the typical plots, and the applications section.

The first page is the advertising page. Most companies' marketing departments have the final say on the first page's contents. This page is where you'll find a concise list of the device's salient features, which will give you a general idea of whether the part will fit your requirements. It will also give you an idea of the types of applications for which the manufacturer designed the part.

Most of these lists don't tell you the conditions under which these specifications apply. And for some carelessly written data sheets, the numbers on the front page don't even match those listed in the performance tables. Somewhat worse, seeing all of these specs listed together subtly implies that the part can exhibit them simultaneously. This implication is not necessarily true. The front page states the best the part can do in a few different categories, but not necessarily all at once or for a particular package style or for a particular temperature-range version.

The front page of the data sheet will invariably use all sorts of adjectives, such as low, high, and true, to describe the part. Those words don't mean much of anything without numbers and test conditions to put them in perspective. For example, the term "true" as applied to an ADC generally means the differential nonlinearity is <1 LSB. However, differential nonlinearity is a dc specification, and an ac specification may be more pertinent to your design. Even with a converter described as having "true" linearity, the effective number of bits with your input signal's frequency can be much lower than you expect.

Editor's analysis: Going beyond data-sheet gripes

Picking apart a data sheet becomes second nature with experience. As an editor evaluating and writing about analog components, I've had plenty of practice trying to select specifications to put into comparison tables.

But even with all this practice, the exercise is often extremely frustrating. Even if I'm successful finding all minimum or maximum specifications (it usually isn't equitable to compare typical specs for reasons discussed in this article), the test conditions under which these guarantees apply are never identical. With each new data sheet I pick up, I have to be as exacting in reading it as the last one. Tabulating specs so that the readers of EDN can do a fair apples-to-apples comparison is a never-ending search and double check of piles of data sheets.

Although analog-component data sheets are pretty well written, I've got my share of complaints about them. I find it annoying when typical ratings are touted on the first page but they aren't clearly stated as typical. I don't like wasting the time it sometimes takes me to discover that the great specs touted on the first page only refer to the high-grade version, which is ten times more expensive than the lowest-cost version. I don't think there's any excuse when numbers on the first page don't even match those in the electrical table (it happens more often than you might think). I refuse to draw any conclusions about a part from an incomplete data sheet that doesn't clearly state the definitions, test methods, and conditions.

Despite these gripes, most data sheets do contain the information you need if you take the time to look for it. Ultimately, a data sheet is just one tool to help you select the most appropriate analog components. You don't buy a data sheet—you buy a part. That part has to perform in a real circuit and system. To measure the part's performance, its designer invariably used just the right layout, just the right support-circuitry component values, and tested the part in just the right environment. Properly reading data sheets requires a constant search for the answer to the following question: what do I have to do—and how hard will it be—to make this part perform as specified? A good data sheet should provide the answers.

EVALUATING ANALOG COMPONENTS

Other words on the front page can be misleading. Don't assume you know what "advanced" and "preliminary" mean—not every company applies the same definition. Either one of these words can mean that the part is currently being designed and only target specs are available, or the part actually has been built and is very close to production.

Every company has a different commitment to advanced and preliminary parts. Some will absolutely deliver them to the marketplace despite extra time and design effort required, others may not if the part proves too difficult to produce. Given these terminology differences, the safest route is to make sure samples are available before you make any decision about a part.

Once you've got the gist of the part from the front page, quickly move on. Barry Harvey, a designer at Elantec Inc, advises "read the first page once and never again." One of the next things you should check is whether these front-page specs match the guaranteed numbers in the electrical tables. You can almost guarantee that if the manufacturer doesn't state it, the

Make converting units second nature

One of the frustrating things about comparing parts occurs when each manufacturer chooses to use different units for the same specification. To quickly compare parts, it helps to be able to quickly converts units, particularly when it comes to ADCs.

According to the application engineers interviewed for this article, equating an ADC's accuracy in percent to accuracy in LSB is a confusing point for many users. The LSB unit is a straightforward way to think about linearity error, but percent a more nebulous.

You can use various algebraic manipulations to equate LSB to percent. For example, 0.01% of a 10V full-scale range is 1 mV. A 12-bit converter has 2^{12}, or 4096, discrete levels. Dividing 10V by 4096 yields 2.4 mV. Since 2.4 mV equals 1 LSB, the error of a 12-bit, 0.01% linear converter is approximately 0.5 LSB (1 mV divided by 2.4 mV).

You can perform similar calculations for converters with different resolutions and percent accuracies. But instead of having to go through the calculation every time, Datel has printed a handy conversion table on its product selection guide for precision, high-speed data-acquisition and conversion components. **Table A** is an excerpt from this table. To use **Table A** for the above calculation, notice that for a 12-bit converter, the LSB weight in percent is 0.024414. Thus, since 0.01% is roughly half of 0.024414%, 0.01% equates to 0.5 LSBs. Similarly, for a 16-bit converter, 0.003% is roughly equivalent to 2 LSBs because 0.003 is twice the 0.001526 value in the table. (Note: Make sure you use full-scale *range*, as opposed to full-scale numbers, for your calculations or when you compare specs to this table. Full-scale range for a converter with a 10V unipolar input or a ±5V bipolar input is 10V. Full scale for the bipolar version would only be 5V, a number which may make the percent linearity number look twice as good.)

Table A—ADC conversion

n Bits	States 2^n	LSB weight $1/2^n$	LSB weight in ppm	LSB weight in % of full-scale range	Bit weight or LSB for 10V FSR
0	1	1.000	1,000,000	100	10.000 V
1	2	0.500	500,000	50	5.000 V
2	4	0.250	250,000	25	2.500 V
3	8	0.125	125,000	12.5	1.250 V
4	16	0.062500	62,500	6.25	625.000 mV
5	32	0.031250	31,250	3.125	312.500 mV
6	64	0.015625	15,625	1.5625	156.250 mV
7	128	0.007812500	7812.500	0.781250	78.125 mV
8	256	0.003906250	3906.250	0.390625	39.063 mV
9	512	0.001953125	1953.125	0.195312	19.531 mV
10	1024	0.000976562500	976.562	0.097656	9.766 mV
11	2048	0.000488281250	488.281	0.048828	4.883 mV
12	4096	0.000244140625	244.141	0.024414	2.441 mV
13	8192	0.000122070313	122.070	0.012207	1.221 mV
14	16,384	0.000061035156	61.035	0.006104	610.352 μV
15	32,768	0.000030517578	30.518	0.003052	305.176 μV
16	65,536	0.000015258789	15.259	0.001526	152.588 μV
17	131,072	0.000007629395	7.629	0.000763	76.294 μV
18	262,144	0.000003814697	3.815	0.000381	38.147 μV
19	524,288	0.000001907349	1.907	0.000191	19.073 μV
20	1,048,576	0.000000953674	0.954	0.000095	9.537 μV

(Courtesy Datel Inc.)

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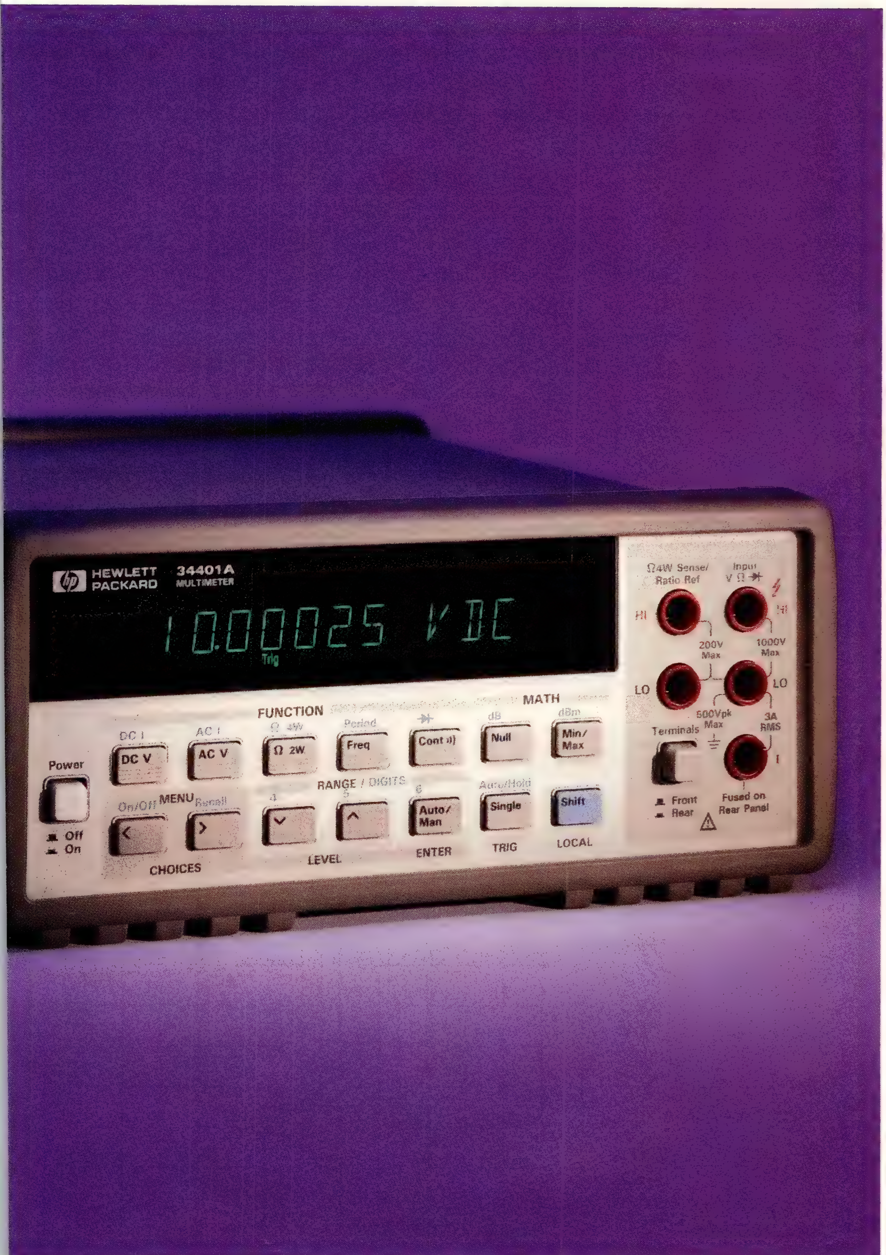

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CIRCLE NO. 135

EVALUATING ANALOG COMPONENTS

spec listed on the front page is a typical spec. You'll have to go to the tables for the guaranteed maximum and minimum specifications.

A quick way to get through the tables is to only look at the units column. Focus on dB, MHz, or mV to quickly locate the parameter(s) you're most interested in. Unfortunately, not all specs will be in terms of the units you expect (see **box**, "Make converting units second nature").

It's easy to gloss over the absolute-maximum-ratings table, but make sure you don't misinterpret it. This table only indicates those extreme conditions that a given part can survive for some undisclosed short period of time. In most cases, if you operate a part at the maximum ratings, the performance of the part will degrade rapidly. In extreme cases, exceeding these limits will permanently damage the parts. For example, CMOS parts may latch up, or you can permanently change the input offset of an op amp by exceeding the differential-input voltage limit.

The problem with basing your design on typical specs is that the definition of "typical" is completely open to interpretation by the companies and even different individuals who write data sheets at the same company. Typical specifications are sometimes generated by the performance of 1000 parts or by the design engineer sitting down with 10 parts and "getting a feel" for the average performance in a few key specifications.

Some companies have standard definitions of what typical means and some do not. For example, Linear Technology's "typical" designation means that more than half the parts will meet or exceed that spec. To make its definition of typical even more obvious, Linear Technology started using histograms to show distributions of various parameters, including offset voltage, offset-voltage drift, and noise. The company's data sheet of the LT1112 and LT1114 precision op amps contains eight histograms. Analog Devices also publishes a histogram to show the distribution of the total unadjusted error of a 12-bit DAC (**Fig 1**).

Because not all companies have a standard definition of "typical" and each designer who writes a data sheet may come up with his or her own definition, determining how conservative or aggressive a typical spec is can be difficult. One clue is to compare the typical to the maximum or minimum specification. You should be suspicious of large, orders-of-magnitude differences. Big differences can mean that there were testing limitations. But it may also mean that the "typical" device exhibits the best performance you're ever likely to see.

Although selecting a component based on its typical specification isn't ideal, you sometimes have no choice. Testing dynamic characteristics of high-speed parts is difficult, and manufacturers often charge much higher prices for those parts that come with guaranteed performance numbers.

Checking the tables' guaranteed numbers goes hand in hand with noting all the pertinent definitions and then the test methods and conditions. The many frequency-domain specifications of an ADC is an

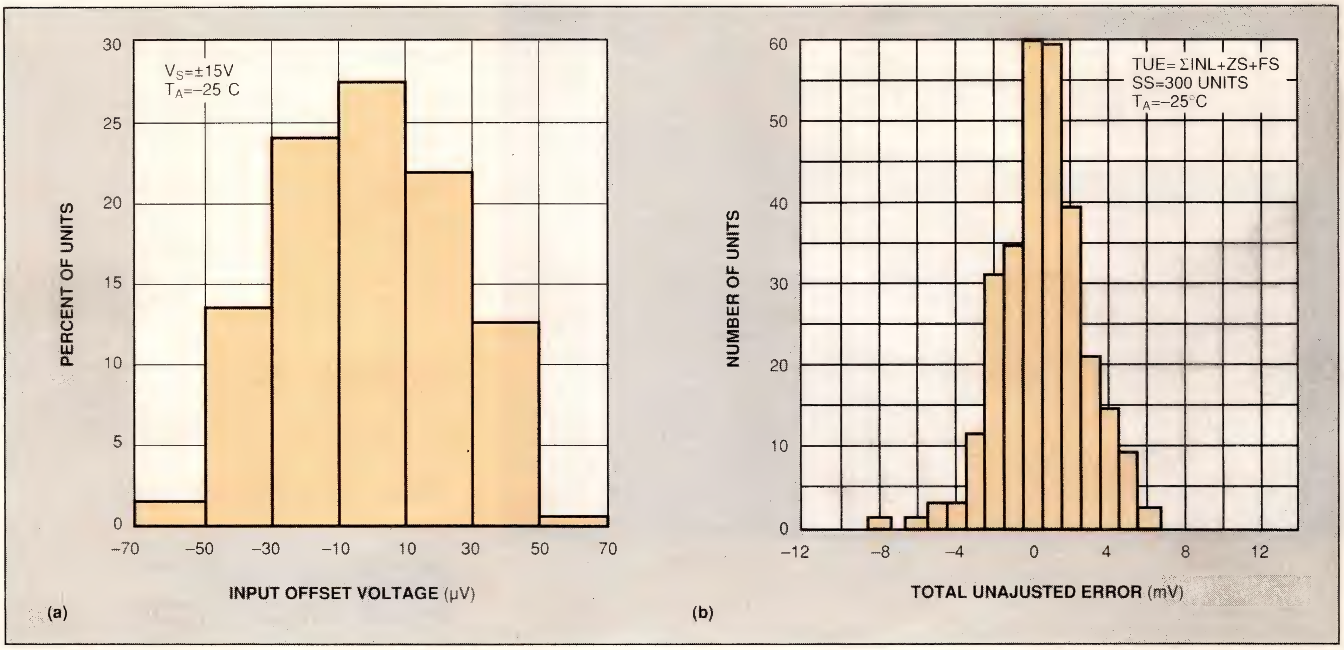

Fig 1—Histograms provide more information than just the typical and guaranteed numbers by showing the performance distribution of a particular parameter. Linear Technology uses histograms to show the range of voltage offset (a) and a few other parameters of some of its precision op amps. Analog Devices' histogram in (b) shows the range of total-unadjusted-error values for a DAC.

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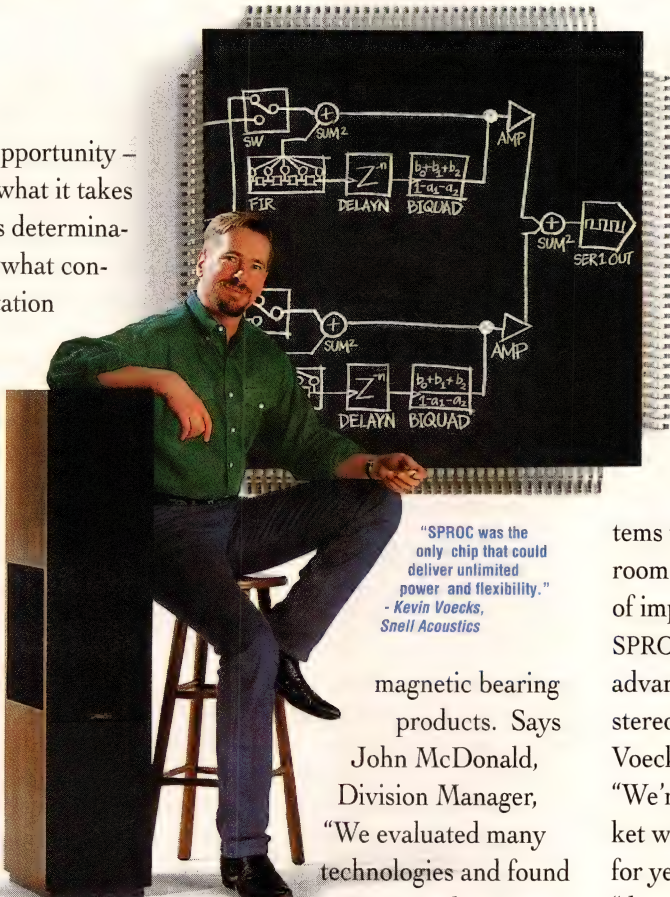

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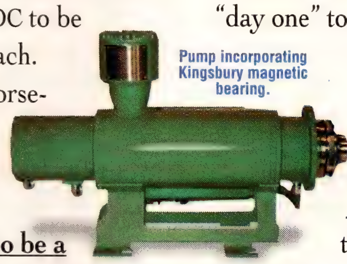

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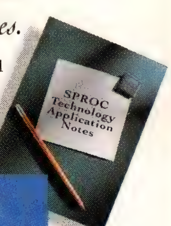

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CIRCLE NO. 107

EVALUATING ANALOG COMPONENTS

extreme case in which many definitions, test conditions, and test procedures have tremendous bearing on the specified parameters. (Datel Inc devotes a seminar and an application note to explaining these specifications and their relationships (**Ref 1**).)

For example, many key specifications describe an ADC's frequency-domain performance, including S/N ratio without distortion; S/N ratio with distortion; total harmonic distortion; peak distortion; spurious-free dynamic range; in-band harmonics; 2-tone intermodulation; and effective number of bits. Some specifications, such as spurious-free dynamic range and peak distortion, mean virtually the same thing.

An ADC's linearity specification can differ depending on whether the manufacturer uses a best-fit straight line or end-point definition. According to Jerome Johnston, applications manager at Crystal Semiconductor, the end-point method generates more conservative specifications that are easier for you to reproduce.

Finally, you should always check under what conditions the specs in the table apply. A list of test conditions will either be in a column in a table, or listed with other notes, sometimes in fine print. Test conditions may not exactly match your circuit's operating conditions, but the conditions should at least make sense, like specifying the output swing of an amplifier with a reasonable load.

Not only is it important to note all the test conditions, but it's important to look for cases when the test conditions vary from spec to spec. If the test conditions are all the same for most specs, but drastically different for a few, you should find out why. The test may be impossible to perform under certain conditions, but it also may be true that the differing test condition made this specification look better.

Checking the temperature performance of a part can give you some strong clues to its overall performance. Datel emphasizes that all its final data sheets' minimum and maximum specs apply over the entire operating temperature range. This is not true for all data sheets. Some will have a few specs that apply only at 25°C and a few that are guaranteed over temperature.

Even though you may not need to know the operation at the temperature extremes, this information can be useful. Many manufacturers trim certain parameters at room temperature, which makes the specs look particularly good at that point. But since no product stays at one temperature its whole life, it's interesting to see what these parts do over temperature.

Vendors choose certain test conditions for one reason: They want to showcase a part's performance.

Always remember that the manufacturer chooses certain test conditions for a reason: to showcase the part's performance. Rarely will your conditions exactly match those that the manufacturer uses in the data sheet. However, you can get an idea of the part's performance under other conditions by using the typical performance curves.

These curves can be a valuable tool to extrapolate between the manufacturer's test conditions and your operating conditions. They can also help you explain certain design phenomena you see when you actually use the part.

You can use the typical curves to get an idea of what a min or max spec might be under a particular condition. One technique, suggested by Bill Gross, design manager at Linear Technology, is to modify the values from a typical curve by the ratio of the minimum and typical numbers in the performance table. For example, suppose you would like to know what the slew rate of an amplifier might be at a given temperature. The table lists a minimum and typical spec at 25°C of 1 and 2V/µsec, respectively. However, a curve shows typical slew rate over temperature.

According to Gross, if you multiply the slew rate from the typical curve at the temperature of interest by the ratio of the minimum and typical number in the table, in this case ½, you come very close to predicting the amplifier's minimum slew rate at that temperature. Because many ac parameters aren't guaranteed over temperature, this method may give you the best idea of what the performance at a specific temperature will be.

Keep the data sheet handy

Finally, most good data sheets contain important applications information about how to physically and electrically use the part. This application section can also be a form of advertising because the company may include a number of dazzling circuit configurations. However, most application notes include honest and practical advice. Most data sheets suggest circuit configurations, component values, and for high-speed devices, layout and supply-bypass guidelines.

Perusing the application notes should give you some idea of how touchy the part is and what kind of effort it takes to make the part perform to its potential.

The phone number for applications assistance is an important part of a data sheet's information. Application engineers can help you out specification nomenclature and help narrow down which of their company's parts best suit your circuit. Once you select a part, they can

also help you optimally apply it. Application engineers are a source for change. Let them know if you find their way of specifying things confusing or misleading and press for change. EDN

Reference

1. Bob Leonard, "Understanding data converters' frequency domain specifications," Application Note, AN-4, Datel Inc, 1991.

Acknowledgment

The author wishes to thank the following companies, whose staffs provided thoughts and information for this article: Analog Devices Inc (Norwood, MA), Analogic Corp (Peabody, MA), Burr-Brown Corp (Tucson, AZ), Comlinear Corp (Fort Collins, CO), Crystal Semiconductor (Austin, TX), Data Translation (Marlboro, MA), Datel Inc (Mansfield, MA), Elantec (Milpitas, CA), Exar Corp (San Jose, CA), Harris Semiconductor (Melbourne, FL), ILC Data Device Corp (Bohemia, NY), Linear Technology Corp (Milpitas, CA), Micro Power Systems (Santa Clara, CA), Motorola (Phoenix, AZ), National Semiconductor (Santa Clara, CA), Sipex Corp (Billerica, MA), and Texas Instruments (Dallas, TX).

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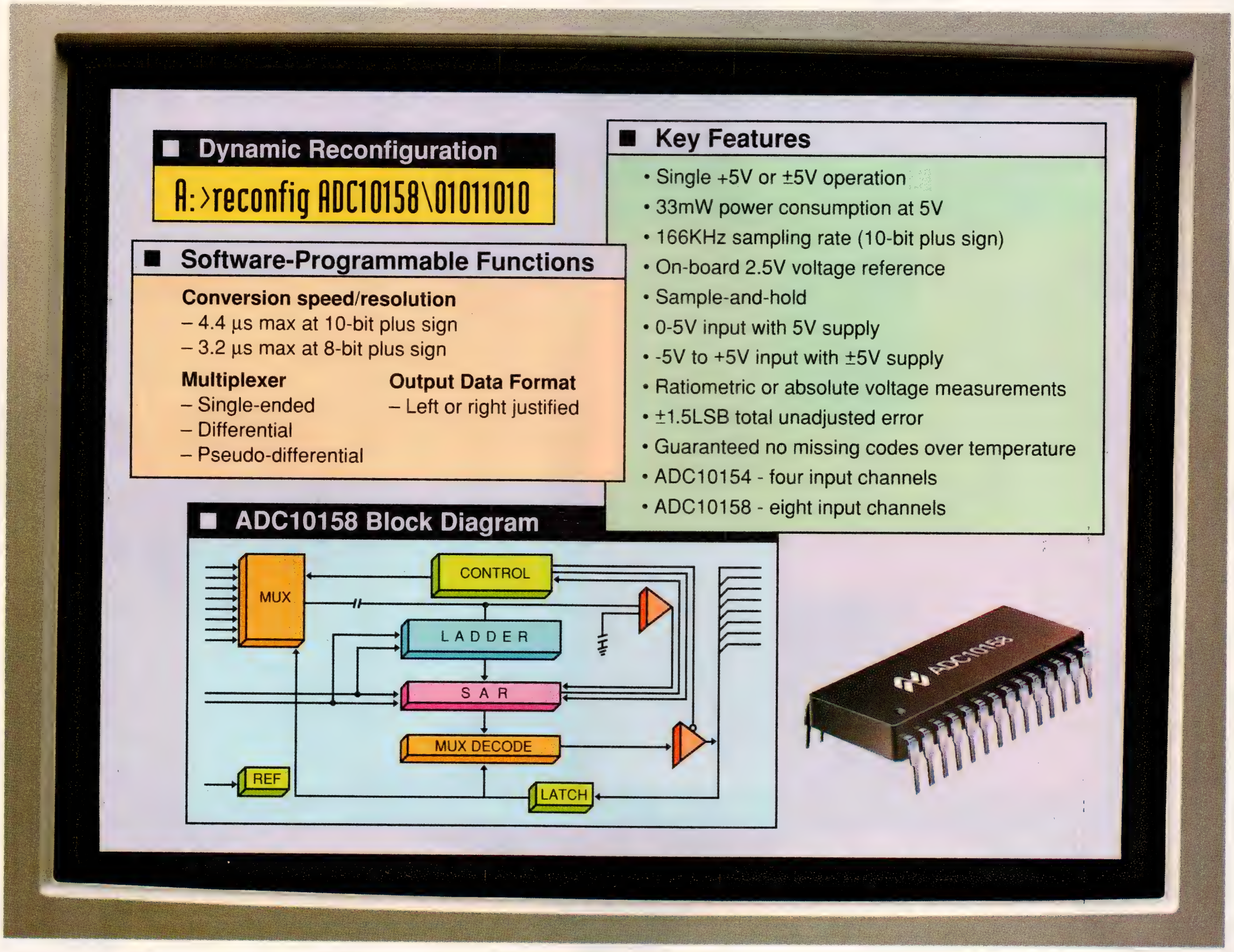

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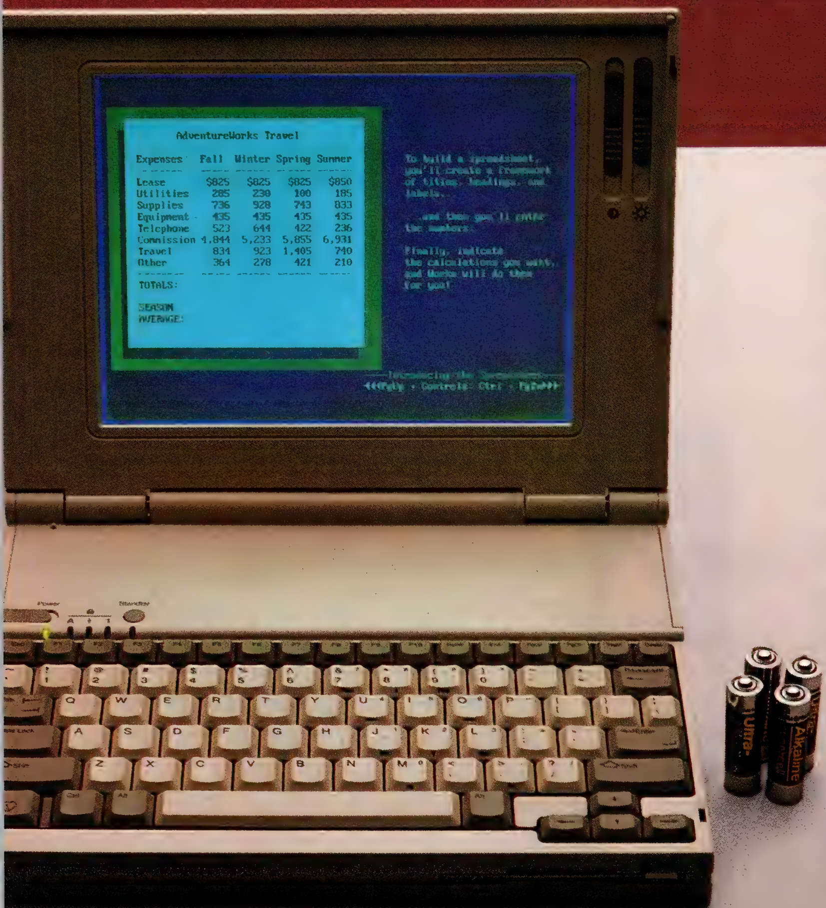

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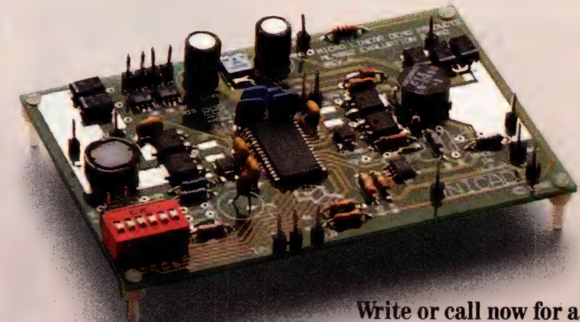

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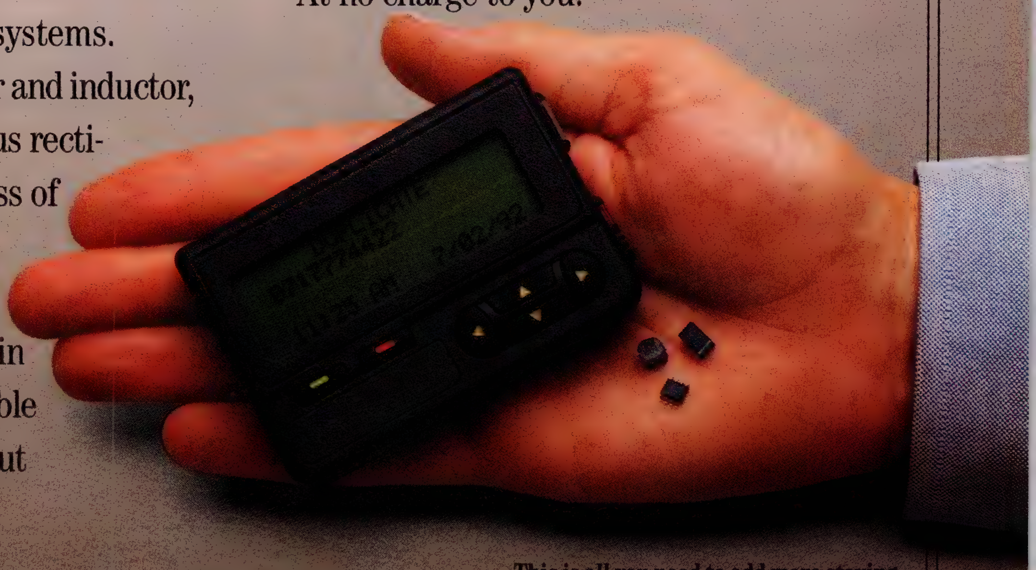

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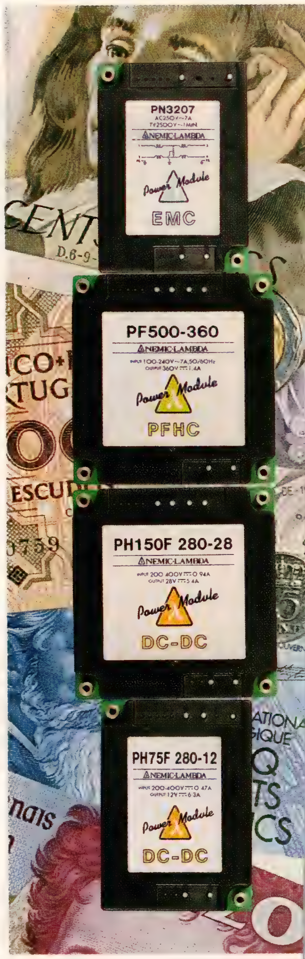

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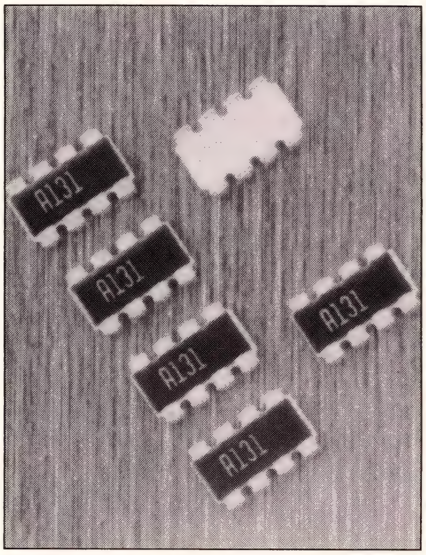

Ceramic chip resistor network. The MNR-34 houses four resistors in a 5.2×3.1-mm package. The device's resistance ranges from 100Ω to 330 kΩ. The surface-mount network dissipates 1/16W and is rated for 50V max. Terminal pitch is 1.27 mm. The concave shape of the electrodes promotes self-alignment during reflow soldering and minimizes the opportunity for bridging between adjacent electrodes. The network is available in 4000-piece tapes. $0.052 (50,000). Delivery, 10 weeks ARO. **Rohm Corp,** Antioch, TN. Phone (615) 641-2020, ext 116. Fax (615) 641-2022. **Circle No. 549**

Closed-loop buffer. The HFA1113 closed-loop buffer combines a 850-MHz −3-dB bandwidth and a 2050V/μsec slew rate. These specs suit the device for video, imaging, and high-speed communications applications. The current-feedback buffer has a programmable output-voltage clamp and a programmable gain (+2, +1, and −1). Other features include an 11-nsec settling time to 0.1%, 0.075-dB gain flatness at 200 MHz, 0.02° differential phase error, and 0.02% differential gain error. In SOICs and plastic DIPs, $5.95 (100). **Harris Semiconductor,** Melbourne, FL. Phone (800) 442-7747, ext 7090.
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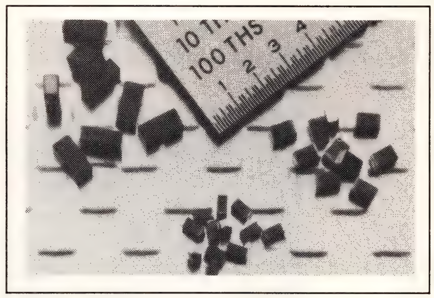
Color-palette ICs. The MU9C4910 and 4910V are monolithic 24-bit color palette ICs; the MU9C9910V 24-bit color-palette IC includes two programmable clock synthesizers. All three ICs display 256 colors from a palette of 262,144 colors, and in direct color mode can display up to 16.8M colors. The three ICs also comply with the VGA, Super VGA, TIGA, VESA, and 8514/A industry standards. The ICs have an asynchronous μP interface, three 8-bit DACs, and a 256-word×18-bit look-up-table RAM. They can handle pixel rates up to 125 MHz and resolutions up to 1280×1024 pixels. One of the MU9C9910V's two synthesizers has eight programmable clock rates and functions as a video-dot clock. The second has two clock rates and can function as a controller or frame-buffer refresh clock. MU9C4910/4910V in 28-pin DIPs or 44-pin PLCCs, $6 (1000). 90-MHz MU9C9910V in 44-pin PLCC, $5.45 (1000). **Music Semiconductors,** Colorado Springs, CO. Phone (800) 788-6874. **Circle No. 551**

HSpice release. The H92A release of the HSpice analog-circuit simulator for digital IC designs can handle circuits as large as 100,000 transistors. The simulator features a time-step control algorithm that automatically adjusts the circuit's time-step size according to circuit activity. The algorithm speeds simulation runtimes with no accuracy loss. Users have the option to shift priorities among convergence, accuracy, and speed. In case of a convergence failure, the simulator automatically performs the "damped pseudo-transient" algorithm, which progresses through an iterative process to reach convergence. The software includes new models from TI, Sharp, and VLSI, as well as models for Intel's PCI high-speed local bus and AMD's advanced EPROM. Also included are an enhanced Berkeley BSIM 2 model, a geometric bipolar model, and a submicron MOS model. The simulator is available on Sun, DEC, IBM, HP, Apollo, and Silicon Graphics workstations; Cray and VAX computers; and 386- and 486-based PCs. $4000 to $120,000, depending on computer or workstation. **Meta-Software Inc,** Campbell, CA. Phone (800) 346-5953; (408) 369-5400. Fax (408) 371-5638. **Circle No. 552**



Ceramic chip capacitors. The terminations of MCS Series capacitors are applied to the ceramic via a dry thin-film bonding instead of immersing the devices in plating solutions. This method reduces the risk of insulation-resistance failures, increases the adhesion and resilience of the ceramic-termination bond, and provides solder heat resistance to 400°C. Capacitance values for the MCS18 range from 220 to 150,000 pF; the chip comes in a 1.6×0.8-mm package. The MCS21 ranges from 680 to 680,000 pF and comes in a 2.0×1.25-mm package. It ranges from 820 to 1,500,000 pF and comes in a 3.2×1.6-mm package. $0.026 to $0.085 (100,000). Delivery: stock to nine weeks ARO. **Rohm Corp,** Antioch, TN. Phone (615) 641-2020. **Circle No. 553**

SAW filters. A series of SAW filters are available for cellular phones. The HWC series comes in 3.5×3.5×1-mm surface-mount packages. Representative filters include the HWCA605, which has a bandpass of 824 to 849 MHz, and the HWCB605, which has a bandpass of 869 to 894 MHz. Typical specifications include 28-dB attenuation; 3.5-dB insertion loss; 2.5-dB inband VSWR, and 68 ppm/°C temperature coefficient for center frequency stability. \$3.65 (10,000). **Hitachi America Ltd,** S & IC Div, 2000 Sierra Point Pkwy, MS-080, Brisbane, CA 94005. Phone (800) 285-1601, ext 06; (415) 589-8300. Fax (415) 583-4207. **Circle No. 554**

8-bit ADCs. The SPT1175 CMOS ADC can digitize analog input signals with full-scale frequency components to 7.0 MHz into 8-bit words at 40M samples/sec. The ADC operates from a single 5V supply and dissipates 90 mW at 20M samples/sec. The device has an internal S/H function and voltage reference and comes in a 24-lead plastic SOIC. The SPT7710 monolithic flash ADC can digitize a 2V analog input signal with full-scale frequency components to 50 MHz into 8-bit words at 150M samples/sec typ. It operates from a single −5.2V supply and dissipates 1.75W (nominal). The ADC features a 300-MHz input bandwidth, 10-pF input capacitance, and metastable errors as low as 1 LSB. The device comes in a 42-lead ceramic DIP. SPT1175, from \$15; SPT7710, from \$75 (100). **Signal Processing Technologies Inc,** Colorado Springs, CO. Phone (719) 540-3900. Fax (719) 540-3970. **Circle No. 555**

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20M-sample/sec arbitrary-waveform generator. The 12-bit-resolution 2414A comes with a library of 20 waveforms. Its 160k-word memory is deep enough to

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Circle No. 557

Pressure-measurement system. The System 8400 integrates with VXIbus systems when connected via the Hewlett-Packard E1414A digitizing interface card. The resulting systems acquire pressure, temperature, strain, voltage, and resistance data at speeds higher than were previously attainable with pressure scanners. Interface card, $7900. Delivery, eight weeks ARO. **Pressure Systems Inc,** 34 Research Dr, Hampton, VA 23666. Phone (804) 865-1243. Fax (804) 766-2644.
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VXIbus switching module with 80 form-C relays. The 1260-17 includes 80 1-wire relays that can switch 1A and 125V and can handle signals at frequencies to 10 MHz. A daughter card installed on the first switching module in the VXI mainframe controls all of the switching modules in the mainframe via the VXI local bus. The daughter card includes a nonvolatile memory for configuration storage. $2295. Delivery, 8 to 10 weeks, ARO. **Racal-Dana Instruments Inc,** 4 Goodyear St, Irvine, CA 92718. Phone (800) 722-3262. **Circle No. 560**

Differential probe kit. The MX9000, an active device, provides selectable ×20 or ×200 attenuation. The probe, which derives power from four AA cells (included) or an optional 6V supply, accommodates signals from 0.1 to 700V. The balanced inputs, which present a high impedance to ground, appear on sheathed pop-jack plugs. The kit includes test-probe handles, spade lugs, fully insulated alligator clips, Mini-grabber to pop-jack leads, and a Nylon accessory pouch. The output is on a standard BNC connector. $315. **ITT Pomona,** Box 2767, Pomona, CA 91769. Phone (909) 469-2900. Fax (909) 629-3317.
Circle No. 561

20M-sample/sec arbitrary-waveform generator. The 12-bit-resolution PM 5150 offers several options for waveform creation: drawing from the front-panel keypad or rotary control; drawing with an optional serial mouse; choosing waveforms from an internal library either singly or—to simulate modulation—multiplied together; and downloading waveforms from a DSO. An optional sequencer allows using predefined or user-defined waveforms in complex sequences. A software package called AnyWave lets you use a PC to create waveforms. $3590; $4695 with sequencer. **John Fluke Mfg Co Inc,** Box 9090, Everett, WA 98206. Phone (800) 443-5853. **Circle No. 562**
Philips Test and Measurement, Building TQIII-4, 5600MD Eindhoven, The Netherlands. Phone local office. **Circle No. 563**

Low-noise wideband op amp. The CLC425 voltage-feedback op amp has a 1.7-GHz gain bandwidth and a 1.05 $nV/\sqrt{Hz}$ noise voltage. Other specs include 1.6 $pA/\sqrt{Hz}$ current noise; 100 μV offset voltage; 2 μV/°C temperature coefficient; 100-dB CMRR; 95-dB PSRR; and 96-dB open-loop gain. The chip operates from ±5V and draws 15 to 5 mA. The slew rate is 350 V/μsec. $4.75 (1000). **Comlinear International,** 4800 Wheaton Dr, Fort Collins, Co 80525. Phone (303) 226-0500. Fax (303) 226-0564.
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20TH ANNIVERSARY

Design tools speed presynthesis system design

The Reveal interactor and Race simulator from Redwood Design Automation are going to change the way engineers design systems. These tools give the system designer the ability to quickly create and simulate high-level models of systems as well as explore design alternatives.

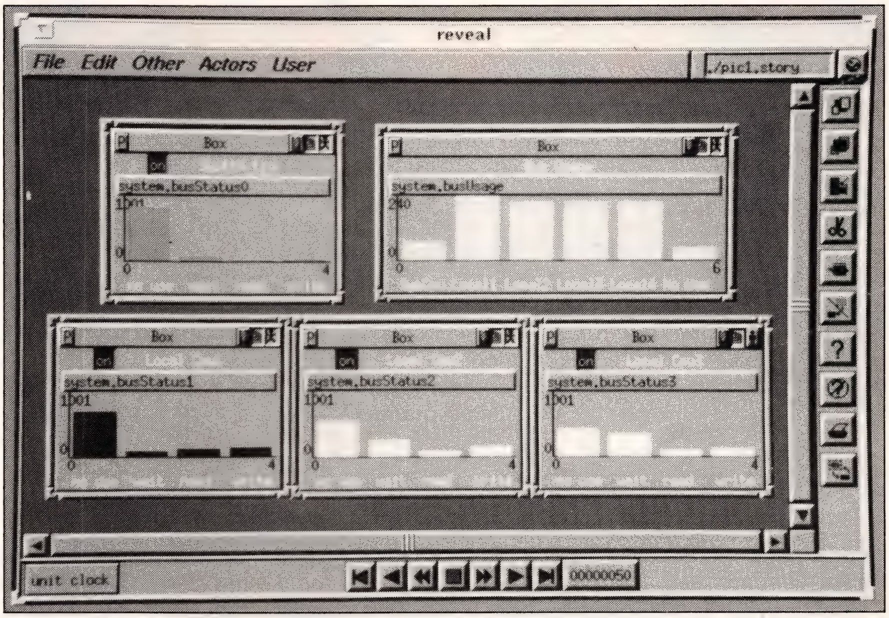
To explore alternative system architectures, you first have to flesh-out designs to run simulation data through the models, and then see how they rate against the performance criteria. These interactor and simulator tools provide a rapid way to simulate, extract, and present the information you need from a simulation to see how well a design satisfies your performance criteria.

The Race simulator runs both Verilog and VHDL (VHSIC Hardware Description Language) code; you can mix them in a single design. Although the simulator doesn't accept all of the VHDL and Verilog languages, it handles most of them. All constructs you can synthesize using Synopsys (Mountain View, CA) tools are a subset of what Race accepts.

The company claims its Race simulator is as much as 100× faster than existing HDL simulators. This speed increase is a result of its clock-cycle-based algorithm (other HDL simulators are event-driven).

The difference between the two types is that event-driven simulators tell you when a signal changed state between clock cycles, but a clock-cycle-based simulator only has to keep track of what changed state during a clock cycle, not when. The Race simulator treats a design as a collection of synchronous logic blocks, although the logic blocks and their communications with each other may be asynchronous.

The clock-cycle-based simulation approach isn't something you want to use for gate-level simulations but for presynthesis design, where timing between clock cycles isn't needed. Hence, the simulator trades unnecessary detail for speed.



As the Race simulation is up and running, the Reveal interactor simultaneously calculates and displays histograms.

The other key component to this product pair is the Reveal interactor. A typical simulator lets you view waveforms and tables of data, just as you might with a logic analyzer attached to the appropriate signals in a real system. This interactor, however, lets you work at the waveform and tables-of-data level if you wish, and it offers the capability of working at much higher levels of abstraction.

You can use the Reveal interactor to create a virtual representation of the system you are simulating. A virtual representation is a simple, animated, graphical depiction that transforms a large amount of simulation data into exactly what you need to know about your system's performance.

Virtual representations for simulation are built using actors, which are Reveal objects that display data based on the simulation state. Actors are easily combined and composed hierarchically by using the mouse to drag and drop actors together—no programming is required.

For example, one of the company's demos simulates a computer cache system. Using the Reveal interactor, you can look at the system performance as cache hit rate vs time, time to execute code, histograms of where processing time is spent, or other virtual representation to get just the information you want. The software generates the virtual representation as the simulation is progressing, so you don't have to wait and postprocess data in a batch mode.

A special capability of the Reveal

interactor makes a simulation appear to run backward. You can set breakpoints in a simulation, stop on a breakpoint, and then back up to see what caused the error. The software doesn't actually run backward; it uses simulation data saved periodically to reach any previously simulated state by running forward from those saved states. The entire operation is transparent to the user, so the simulation appears to back up.

The Reveal interactor and the Race simulation engine are in beta; full production is scheduled for the third quarter of 1993. Initially, the products will be sold together. A single-language version costs $65,000.—**Doug Conner**

Redwood Design Automation, San Jose, CA. Phone (408) 291-3650. Fax (408) 294-2818.

Circle No. 384

New workstations raise performance, lower cost

Three new Alpha-based workstations from Digital Equipment Corp include, according to the company, the world's fastest workstation and the fastest workstations under \$5000 and \$10,000.

The DEC 3000 Model 500X AXP is the high-end model. It's based on a 200-MHz Alpha processor and achieves performance levels of 110.9 SPECint92 and 164.1 SPECfp92. The list price is \$69,999.

Emphasizing highest performance per dollar, the DEC 3000 Model 300 AXP uses a 133-MHz processor and performs at 66.2 SPECint92 and 91.5 SPECfp92. It costs \$9695 with 32 Mbytes of memory and a 426-Mbyte disk. Configured with a 19-in., 1280×1024 color monitor, the price is \$12,995.

Of Digital Equipment Corp's three new Alpha-based workstations, Model 500X sets new performance levels, Model 300 increases price/performance ratio, and Model 300L establishes a new low price.

DEC's entry-level model is the DEC 3000 Model 300L AXP, which uses a 100-MHz processor and achieves 45.9 SPECint92 and 63.6 SPECfp92. It sells for \$4995 with 32 Mbytes of memory and no disk; configured with a 400-Mbyte disk and a 16-in., 1024×768 color monitor, the price is \$7920.

The 500X and the 300 are expandable deskside models; the 500X has six Turbo Channel slots, and the 300 has two. The 300L is a desktop model without Turbo Channel slots. The 500X can accommodate 256 Mbytes of memory; the 300 and 300L top out at 64 Mbytes. Likewise, the 500X's 4.2 Mbytes of in-cabinet disk storage exceeds the 300's and 300L's 2 Gbytes.

Compared to DEC's previously introduced Alpha workstations (Model 500 and Model 400), the Model 500X performs significantly better. Its 110.9 SPECint92 and 164.1 SPECfp92 compare to 84.4 SPECint92 and 127.7 SPECfp92 for the Model 500 and to 74.8 SPECint92 and 112.5 SPECfp92 for the Model 400. Figures from DEC comparing the 500X's SPECint92 numbers to competitors' show that the 500X is well ahead of Hewlett-Packard's HP 375 and HP 755 and IBM's RISC 6000 580. For SPECfp92 performance, however, those competing workstations are on the 500X's heels.

DEC claims that among midrange workstations (<\$20,000 for a fully configured system), the Model 300 computes integers faster than all entries from Hewlett-Packard, IBM, and Sun. IBM's RISC 6000 355 does slightly better in floating-point calculations, but costs more. DEC says its Model 300L is the champion in both integer and floating-point performance for all entries in the low-price range (<\$10,000 configured).—**Gary Legg**

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CIRCLE NO. 79

Processor-specific sockets feature controlled impedance

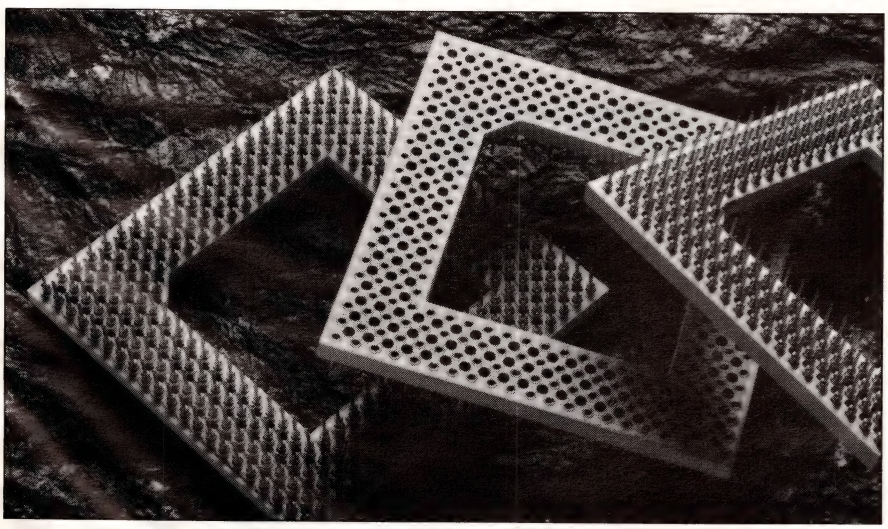
ZGA Series PGA (pin-grid-array) sockets address designers' concerns for capacitance, inductance, and crosstalk issues associated with high-speed-semiconductor use. At the heart of the socket design is an innovative process for creating interconnected ground planes on the top and bottom surfaces of the contact housing. In essence, the design transforms the socket contacts into coaxial-style transmission lines.

The ZGA's socket design utilizes selective metallization of high-performance thermoplastic. Grounding planes and tubes are created around the high-speed signal contacts of the socket, forming pseudo-coaxial transmission links from the device, through the socket, and into the mother board. This design achieves high-frequency isolation and improves crosstalk performance by reducing noise. Characteristic impedance is controlled by strategic placement of ground pins, coupling the socket's ground-mesh patterns to the mother board, the device's ground pins, or a combination of both.

With the ZGA, you can vary the distance between the surrounding ground planes and the signal contacts to design processor-specific sockets that have 50Ω matched impedance signal lines within the socket. The ground planes then connect, via extended plating, to contacts in the socket that mate with selected ground pins on the device. In a processor-specific configuration such as this, the ground pins of the device and socket, as well as the ground planes on the socket housing, are electrically connected to the ground plane resident in the pc board.

The first release of ZGA Series sockets suits Intel's 66-MHz version of the 80486 MPU and the Pentium processor; the ZGA273H509B5-2119-001 (for the Pentium) costs $12.21 (1000).—**Tom Ormond**

McKenzie Technology, Fremont, CA. Phone (510) 651-2700. Fax (510) 651-1020. **Circle No. 387**



To accommodate high-speed ICs, the ZGA Series socket-design process creates interconnected ground planes on the top and bottom of the contact housing. These ground planes encircle each signal pin and interconnect via plated-through holes, transforming the socket contacts into coaxial-style transmission lines.

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Sub-$1000 ADC boards operate at up to 1M samples/sec

The $995 price is the most obvious feature of the Win-30D, a 1M-sample/sec, 12-bit, 16-channel data-acquisition board with 24 digital I/O lines from United Electronic Industries (UEI). Other boards that offer comparable speed and resolution cost between $2395 and $2995. Price is not the Win-30D's only notable feature, though. The board uses the repeat-string (REP INSW) instruction of a host 80386 or i486 μP to transfer conversion results to memory at 1M samples/sec. In this mode, the board uses only 30% of the CPU's cycles. An attempt to make DMA transfers at that speed, even in 256-channel bursts, would use over 100% of the CPU cycles. (That is, the board would have to slow down to 909k samples/sec.)

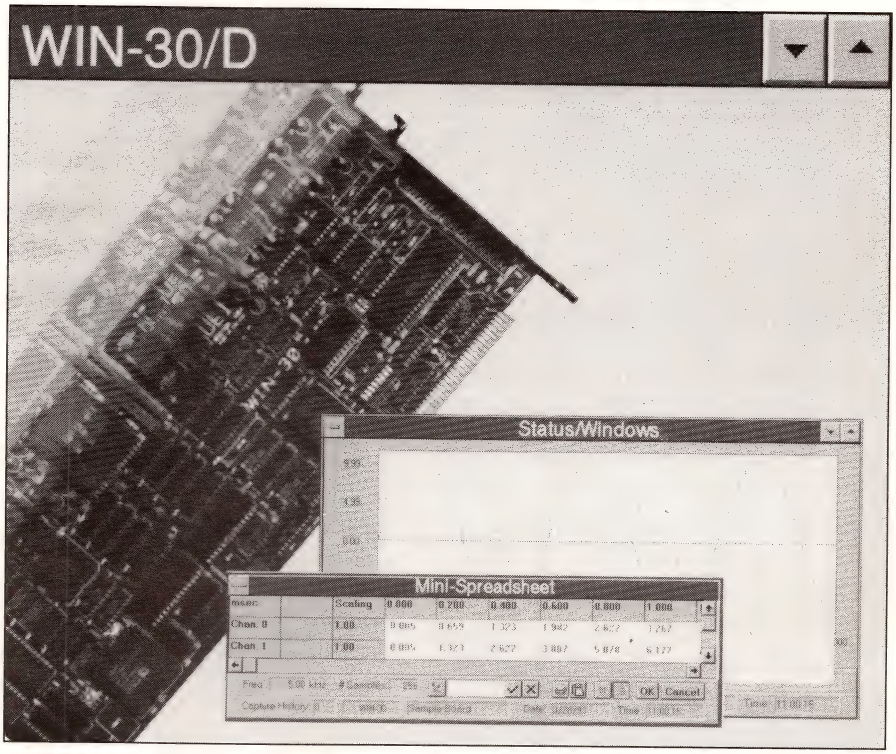
According to UEI, only one other data-acquisition board supplier, Computer Boards Inc (CBI), makes a unit that supports REP INSW. The CBI CIO-DAS16/330i runs at 330k samples/sec, offers programmable gain, and lists for $799. Of late, CBI has been using the slogan "DMA is dead." UEI feels that reports of DMA's death are exaggerated. That is why the Win-30D supports 2-channel, 16-bit DMA as well as REP INSW. (Despite CBI's assertion about the death of DMA, its CIO-DAS16/330i supports single-channel DMA—to provide compatibility with competitive boards.)

The Win-30D can perform DMA transfers either one reading at a time (the maximum rate is about 350k samples/sec) or in 256-channel bursts. With data packing, burst-mode transfers can proceed at the ADC's full 1M-sample/sec speed while using only about 80% of the host CPU's cycles. The 909k-sample/sec rate mentioned earlier was achieved without data packing.

Although data packing is rather straightforward, data-acquisition boards don't use it widely. With data packing, a board like the Win-30D, which plugs into the 16-bit ISA bus, puts four 12-bit values into three 16-bit memory locations, rather then putting the values into four locations and wasting four bits of each. Unpacking is handled by the software driver when it retrieves data from the host memory.

The UEI board uses an AD-2105 DSP μP (from Analog Devices, Norwood, MA), but not to perform DSP operations. The DSP IC manages housekeeping functions, such as implementing channel lists. The $795 DI-200, a feature-laden 83k-sample/sec board announced in January by Dataq Instruments, was the first data-acquisition board to use a DSP chip in this manner. DSP μPs appear particularly well suited to managing data acquisition.

If REP INSW can so outperform DMA, why isn't DMA dead? According to UEI, the reason is the complexity of the software you need to control REP INSW operations. The firm has addressed that problem, though, by creating software drivers. The Win-30D will ship with drivers (written in C) that work with any MS-Windows high-level language supporting dynamic-link libraries; in other words, with all Windows languages that UEI is aware of. UEI will ship the driver source code with the boards. But though the code is fully commented, the comments are too terse to form



At the click of a mouse button, the MS-Windows-based Status/Windows software supplied with UEI's Win-30D board performs a number of functions, including exporting data in a spreadsheet format.

a good tutorial on how to write such drivers.

In addition, drivers for the Windows versions of LabView (from National Instruments, Austin, TX) and Labtech Notebook (from Laboratory Technologies, Wilmington, MA) will accompany the board, as will a Windows application called Status/Windows. This data-acquisition program even does FFTs on the host CPU and exports data both via the Windows clipboard and in spreadsheet formats. Also accompanying the board will be a demo program (with source code) and a calibration program. All of the software is compatible with MS-Windows V3.1 and Windows-NT.

Over the next four months, UEI will introduce additional boards in the Win-30 family, including 12-bit units with simultaneous sample/hold (4 and 16 channels—$1195 and $1495) and 16-bit units that convert at 150k samples/sec (from $995). There will also be 12- and 16-bit boards that offer software-programmable gain. In each ADC word length, you will be able to choose boards that offer gains of 1, 2, 4, and 8 or 1, 10, 100, and 1000. When 16-Mbyte single-in-line memory modules become available, UEI will announce a plug-on card that accommodates 64 Mbytes. (On 1M-sample/sec boards, 64 Mbytes store 32 sec of data without packing.) With the plug-on card installed, the adjacent slot will accommodate only a half-length board.—**Dan Strassberg**

United Electronic Industries Inc, Watertown, MA. Phone (800) 829-4632; (617) 924-1155. Fax (617) 924-1441. **Circle No. 381**

Computer Boards Inc, Mansfield, MA. Phone (508) 261-1123. Fax (508) 261-1094. **Circle No. 382**

Dataq Instruments Inc, Akron, OH. Phone (216) 668-1444. Fax (216) 666-5434. **Circle No. 383**

80C51 microcontroller incorporates 4 kbytes on-chip flash memory

Developing ROM-based, single-chip microcontroller (µC) applications can get tricky for fast-turnaround projects. It takes time to schedule ROM production, and the on-chip ROM code had better be right. With on-chip flash memory, you can create your own program and change it. Even better, you can change portions of code or fixed data for application needs, such as inputing access codes or holding key dynamic data.

Now you can get a flash-memory 80C51 from Atmel. The AT89C51 represents Atmel's first step into the 80C51 µC market. The chip is compatible with the standard Intel-designed MCS-51 architecture, and substitutes 4 kbytes of flash memory for on-chip ROM.

The cost of a flash part is more expensive than that of a ROM part, but you can use flash parts for applications that demand changeable, nonvolatile on-chip memory. Additionally, you can use flash chips for debugging and for prototyping. With flash, you can change the on-chip program code without having to remove the µC from the target board, which requires some special logic. Or you can remove the chip and reprogram it on a standard 12V device programmer.

The µC has a program life of 10 years. You can erase and write to it 100 times. For secure operations, the flash memory has built-in lock protection. When programmed properly, you cannot read the flash-memory contents without using MOVC instructions. Also, you cannot further reprogram the flash memory.

You can write and read code data to or from the flash memory. You can also erase the entire memory prior to filling it. Before modifying the memory, you must set the VPP select code, which defines 5 or 12V operation, by writing one of two values to an SFR location.

A write to the flash memory is self-timed; it takes about 1 µsec. You set up the data and address, and then pulse the ALE/PROG* line to write the byte into memory. You poll the data lines for end-of-the-write cycle. The data is reversed for reads until the write is completed, then true data is valid on all output lines.

The AT89C51 is a fully static design. Clock rates run out to 20 MHz, but can be dropped back to dc to reduce power consumption while waiting for the application processing to resume. Or you can drop power dissipation by dropping into idle or power-down modes, which cut power by turning off peripherals or the oscillator itself, respectively.—**Ray Weiss**

Atmel, San Jose, CA. Phone (408) 441-0311. Fax (408) 436-4300.

Circle No. 386

AT89C51 8-bit µC with flash

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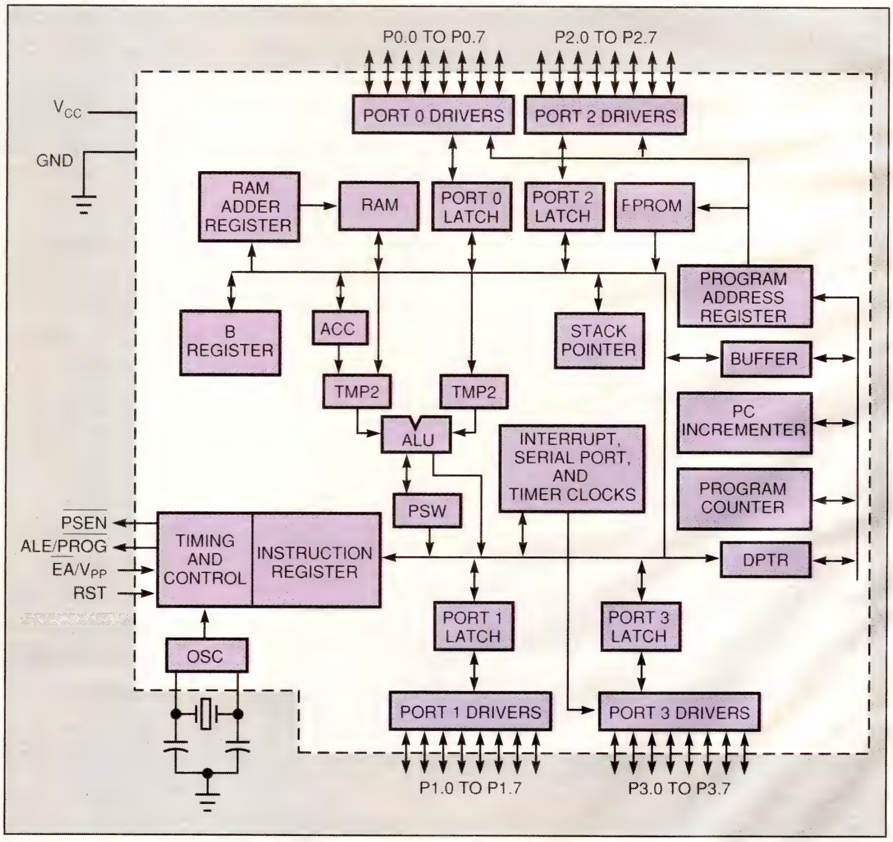

The Atmel AT89C51 is a standard 80C51 with on-chip flash memory. You can change that memory (up to 100 times) on the target board with only V_{CC} voltage.

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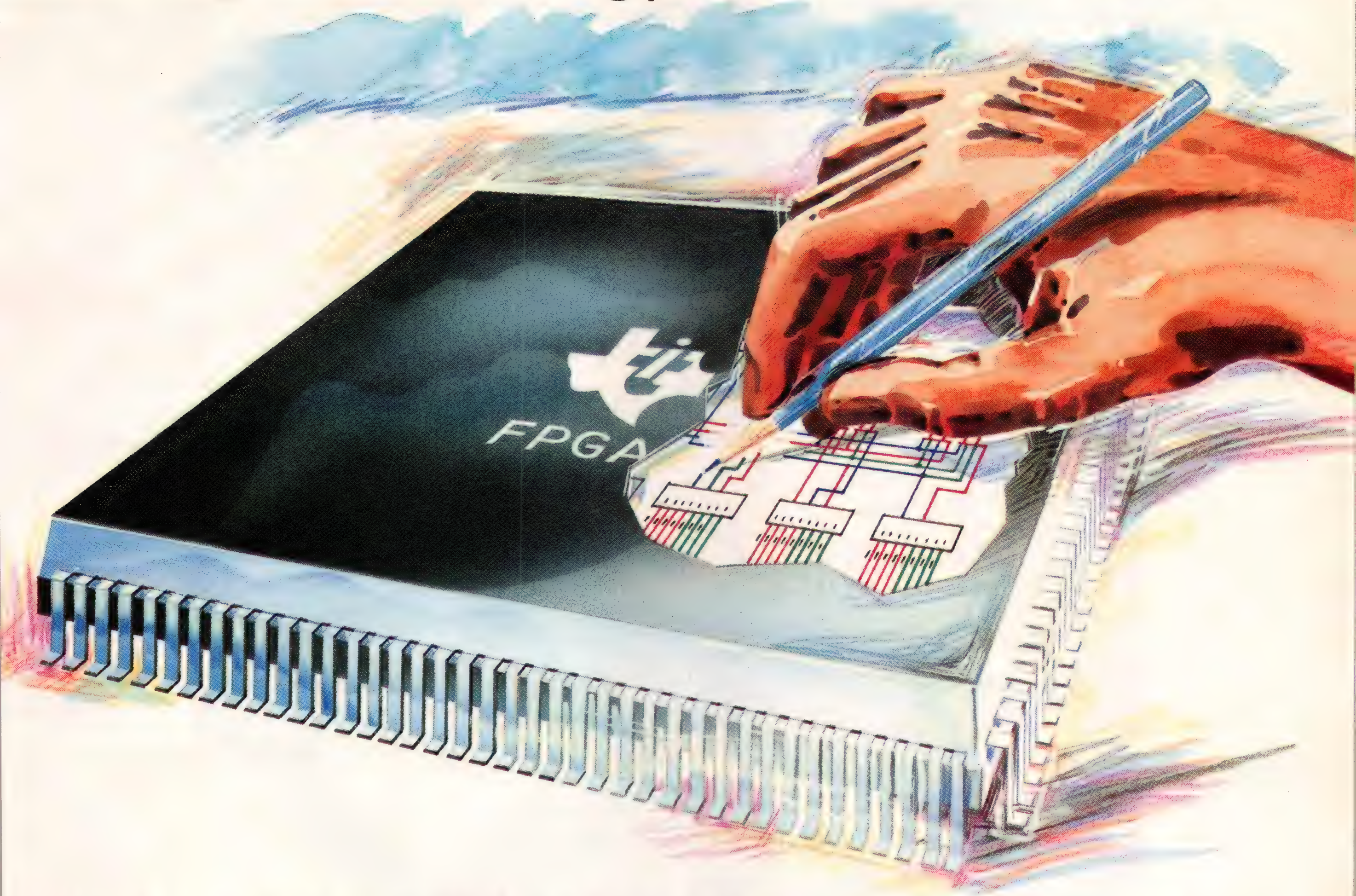

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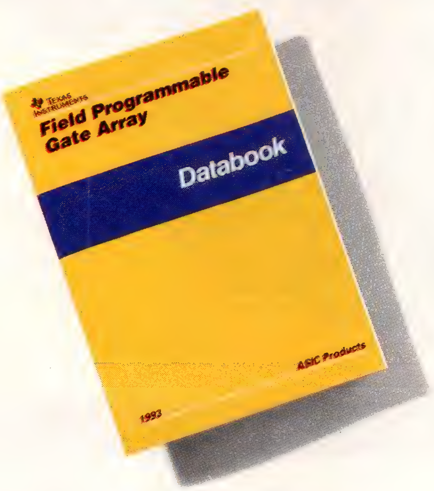

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	2GHz LV-LNA/Mixer/VCO			X			X
IF Strip	Low Power IF Strip	X			X	X	
	IF/Wide BW/Fast RSSI		X	X			X
	Low Power/Wide BW/Fast RSSI		X	X			X
Synthesizer	1GHz/High Performance	X			X		
	1GHz/Fast Lock		X			X	
	Fractional N	X		X		X	X
	1GHz/2GHz Prescaler	X		X			X
Audio Processor	Low Power Compandor	X			X		
	LV/Audio Processor/Compandor	X			X		
	LV/Audio Processor/Filter	X			X		
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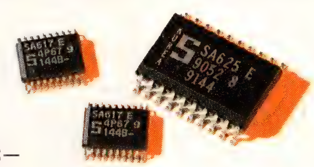

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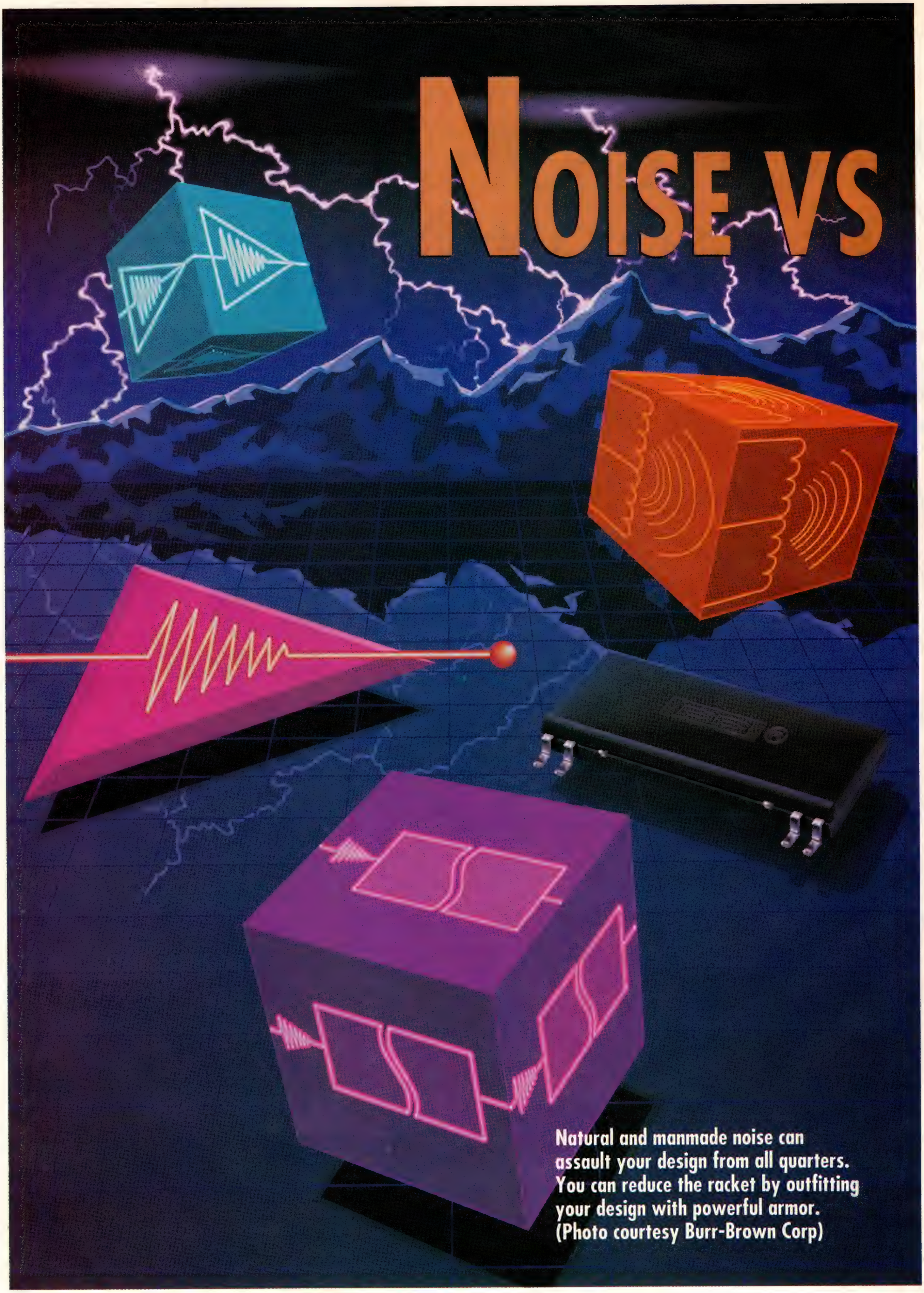


Natural and manmade noise can assault your design from all quarters. You can reduce the racket by outfitting your design with powerful armor. (Photo courtesy Burr-Brown Corp)

SENSITIVE CIRCUITS

CHARLES H SMALL, Senior Technical Editor

So, what's new in the way of noise? Has Boltzman's constant changed? Has copper gone superconducting? Has the price of Mumetal dropped? No, but natually occurring noise continues to be just as nasty a problem as ever, and electrical devices still generate plenty of manmade noise.

What's new in noise is the increasing number of engineers who have to deal with noise who didn't before. For example, two hot applications are fraught with new noise problems for the unwary engineer: digital logic running at clock speeds over ~30 MHz and higher-resolution, higher-speed analog-to-digital or digital-to-analog converters (ADCs and DACs). **Fig 1** offers a comprehensive breakdown of noise problems associated with analog design, digital design, and "mixed-signal" (analog and digital) design. **Fig 1** also shows the analysis methods needed to characterize each noise problem, as well as possible corrective steps you can take.

Table 1 lists the bandwidth, signal-to-noise (S/N) ratio, and harmonic-distortion specs for various examples of high-speed signal processing where such

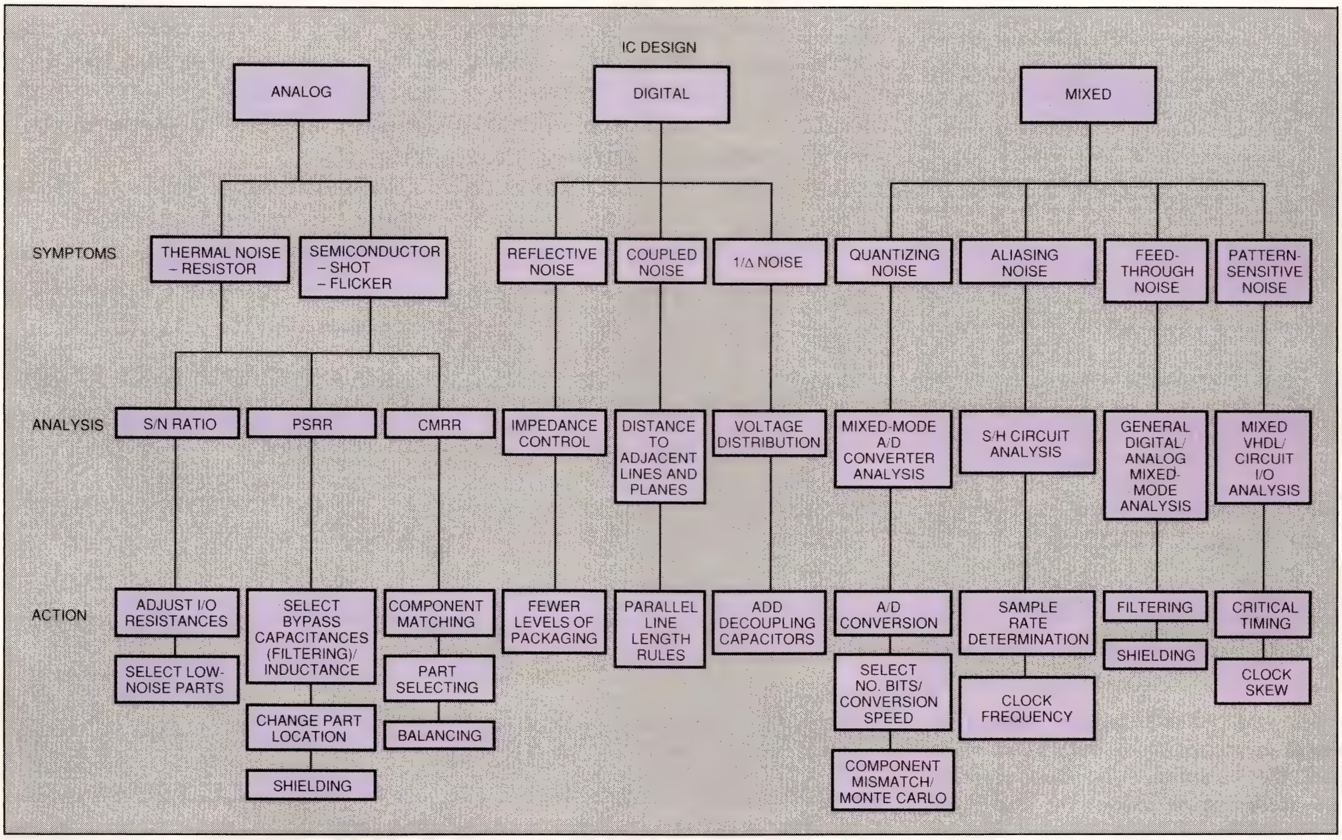


Fig 1—Using this chart, you can relate the different types of IC design to their associated problems and solutions (courtesy Meta-Software).

advanced converters are needed.

Fig 2 shows the S/N ratio you can expect to achieve with various pc-board techniques. A board with no ground plane provides a pitiful S/N ratio; a board with power and ground planes plus metal shields for sensitive components achieves the best S/N ratio. Obviously, as the board's S/N ratio increases, so does its price. Therefore, you may find **Table 1** and **Fig 2** helpful when you must convince your boss to authorize an expensive, multilayered pc board.

Luckily for digital and mixed-signal designers, analog designers have developed design practices and tools that blaze a path to follow. Now designers in other fields may or may not have to handle all of the problems that analog designers must. Certainly, designers working with high-resolution DACs and ADCs face all the traditional noise problems *plus* some noise problems unique to converters. Digital designers, on the other hand, need to worry only about a subset of all noise problems—mostly ground bounce (a form of power-supply coupling) and transmission-line effects.

Table 1—High-speed signal processing dynamic-range requirements (approximate)

Application	Signal bandwidth	Harmonic distortion, SFDR	S/N ratio
Professional video (HDTV)	6 to 30 MHz	–50 to –60 dBc	50 to 60 dB
Medical ultrasound imaging	2 to 15 MHz	–50 to –70 dBc	45 to 60 dB
Digital oscilloscopes	dc to 1 GHz	–35 to –50 dBc	35 to 50 dB
Spectrum analyzers	1 to 10 MHz	–70 to –90 dBc	60 to 70 dB
Broadband receivers	2 to 30 MHz	–40 to –90 dB	45 to 70 dB

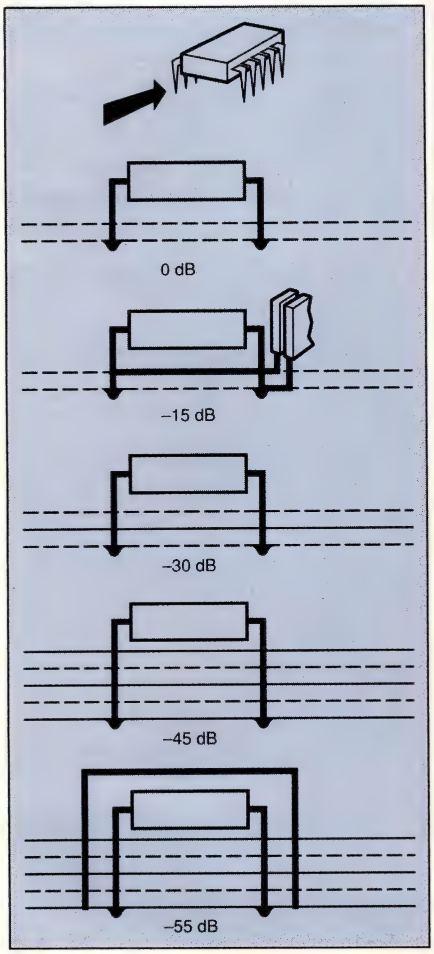
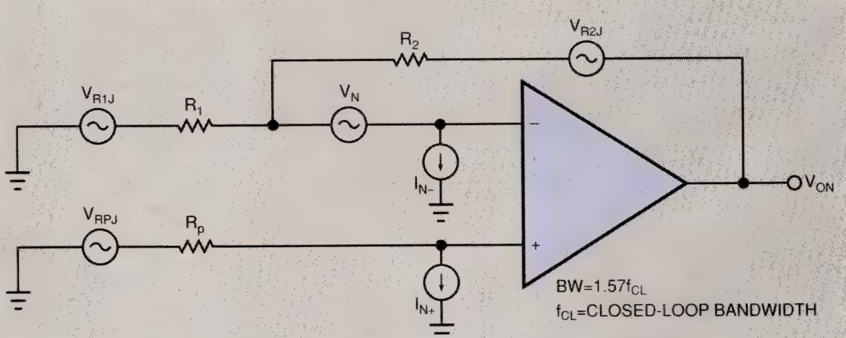


Fig 2—You can kill radiated noise at its source on your pc board. Dotted lines represent the substrate; solid lines represent ground and power planes. The final IC has a 5-sided, metal shield around it (courtesy shielding experts Instrument Specialties).

Noise is simply any unwanted signal. Noise comes from natural sources such as the thermal motion of electrons, electrons flowing in a wire, or various solid-state phenomena. Manmade noise can also sneak into sensitive circuits. Noise on power-supply lines and crosstalk between two lines are examples.

The three noise sources you need to be most concerned about are device, conducted, and radiated noise. Examples of device noise are a resistor's thermal noise, a transistor's shot noise, and an op-amp's $1/f$ noise. If your design requires some form of isolation from the outside world (magnetic, capacitive, or opto isolators), device noise could also come from modulation- or demodulation-ripple, jitter, or optical-device noise. High-performance converters can pick up noise from their reference-voltage source and distortion from jittery clock sources. ADCs' internal sampling circuitry and digital-output circuitry can introduce noise into power-supply lines.

Conducted noise comes in on the conductive paths that connect to your design. It can appear on the



$$V_{ON}=\sqrt{BW}\sqrt{I_{N-}^2R_2^2+I_{N+}^2R_P^2\left[1+\frac{R_2}{R_1}\right]^2+V_N^2\left[1+\frac{R_2}{R_1}\right]^2+4kTR_2+4kTR_1\left[\frac{R_2}{R_1}\right]^2+4kTR_P\left[1+\frac{R_2}{R_1}\right]^2}$$

Fig 3—This model of an amplifier contains all possible noise sources. Savvy designers leave out insignificant noise sources to speed simulations.

power-supply lines, on your design's input lines, or between the grounds of isolated systems. Conducted noise can be a self-inflicted wound if you do not pay attention to grounding and signal runs on your pc board's layout. Grounding is especially tricky for mixed-signal designs because your analog and digital grounds must perforce meet at the ADC or DAC and not just at the power supply's terminals.

Radiated noise occurs in the space around your device. Everything from sunspots and nuclear explosions down to your company's elevator and coffeepot generate radiated noise.

Digital engineers working at lower clock frequencies have taken advantage of their devices' high noise immunity to enjoy a vacation from noise problems. And their digital design tools' rudimentary—or missing altogether—noise-analysis capability reflects digital designers' lack of concern. But no longer. Increasingly, digital designers must perform accurate analog analyses and simulations of their designs and use analog-style practices when laying out their pc boards.

To understand how to inject noise judiciously into a device model, consider the classic op amp in **Fig 3**, which shows all possible input noise sources, including Johnson noise in the circuit's resistors, as well as the equation for calculating output noise, V_{ON}. Analog designers make key simplifications to this model for various applications. For example, if resistances are above 500Ω, they ignore the resistors' Johnson noise. For voltage-feedback circuits, the major noise source is input voltage noise. Similarly, for current-feedback circuits, input-current noise at the inverting input is the most important source. In each case, savvy designers leave out less-important noise terms in order to speed Spice simulations.

In the mixed-signal world, to simulate ADCs and DACs accurately, you should inject noise into analog lines and onto reference-voltage inputs. The same technique can add jitter to phase-locked loop simulations (**Ref 3**). If your version of Spice does not have noise sources, you can enter random values into a Spice PWL table to create your own random-noise source.

Analog behavior of the digital

Fig 4 shows a not-so-subtle candidate for simulation in current digital designs: a distributed clock line. The Spice subcircuit in **Fig 4(a)** calculates the distributed inductance

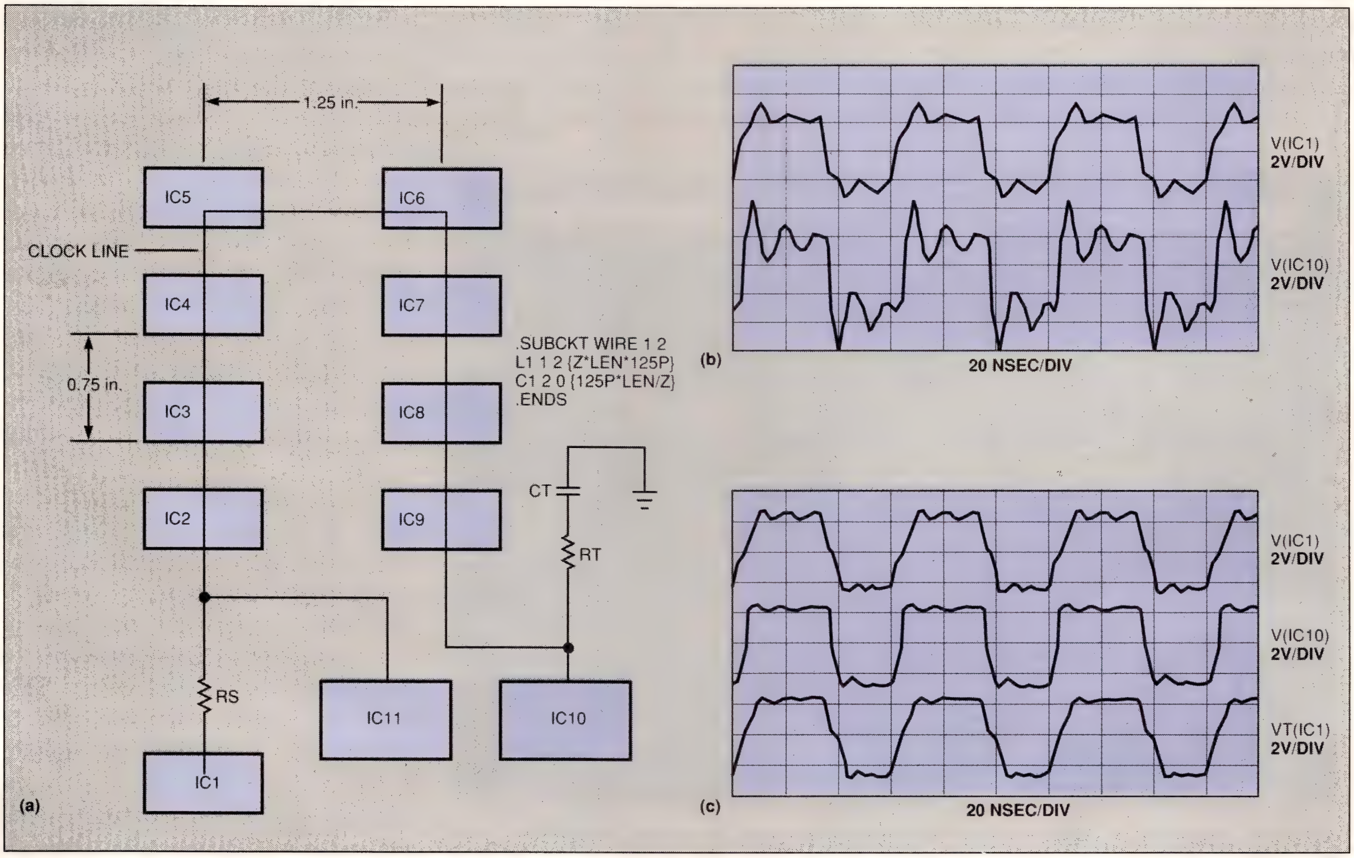


Fig 4—A distributed clock line is a good candidate for simulation. The Spice program in (a) calculates parameters from the line's length (LEN). The results of simulating clock pulses with and without a series-terminating resistor appear in (b) and (c), respectively (courtesy Intusoft).

NOISE VS SENSITIVE CIRCUITS

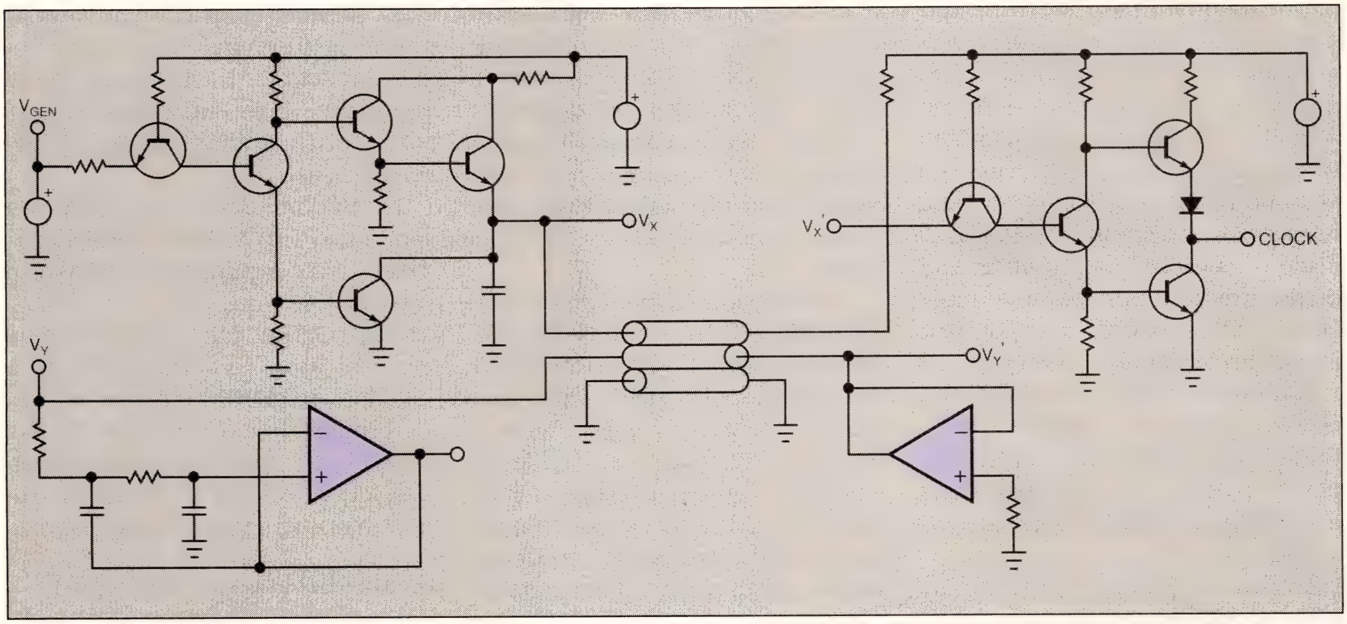


Fig 5—Older versions of Spice, which lack built-in transmission-line models, require elaborate circuits, such as this one, to model coupled transmission lines.

and capacitance of the clock line from its length (LEN). The graphs in **Fig 4(b)** and **Fig 4(c)** show the simulated results of running without and with a series termination of 68 pF and 33Ω (and with a 33Ω source resistor in both cases). These simulations assume that all ICs present a 7-pF load to the clock line. Without accurate models of the individual devices, the simulation is only an approximation, and determining clock skew accurately is particularly difficult.

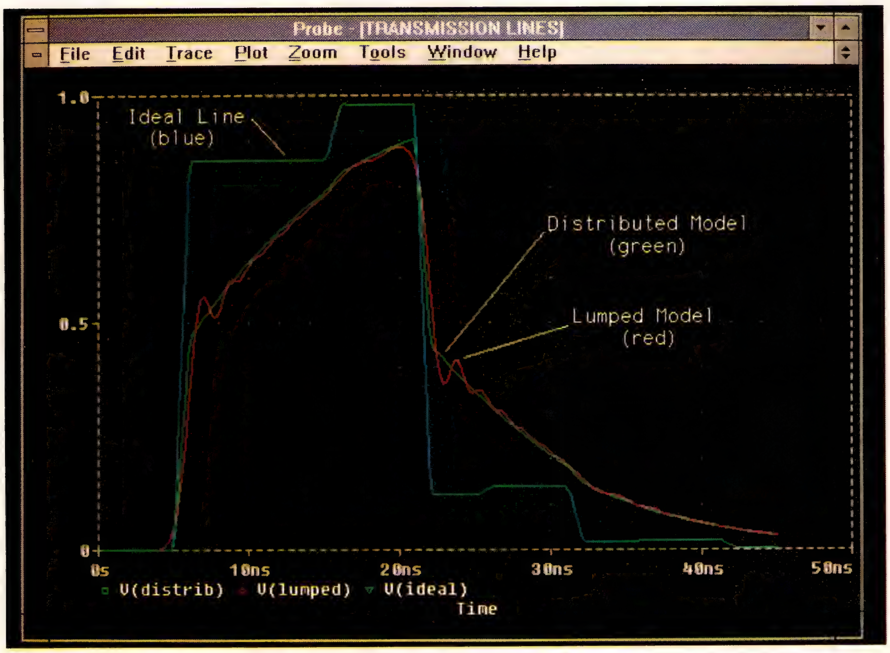
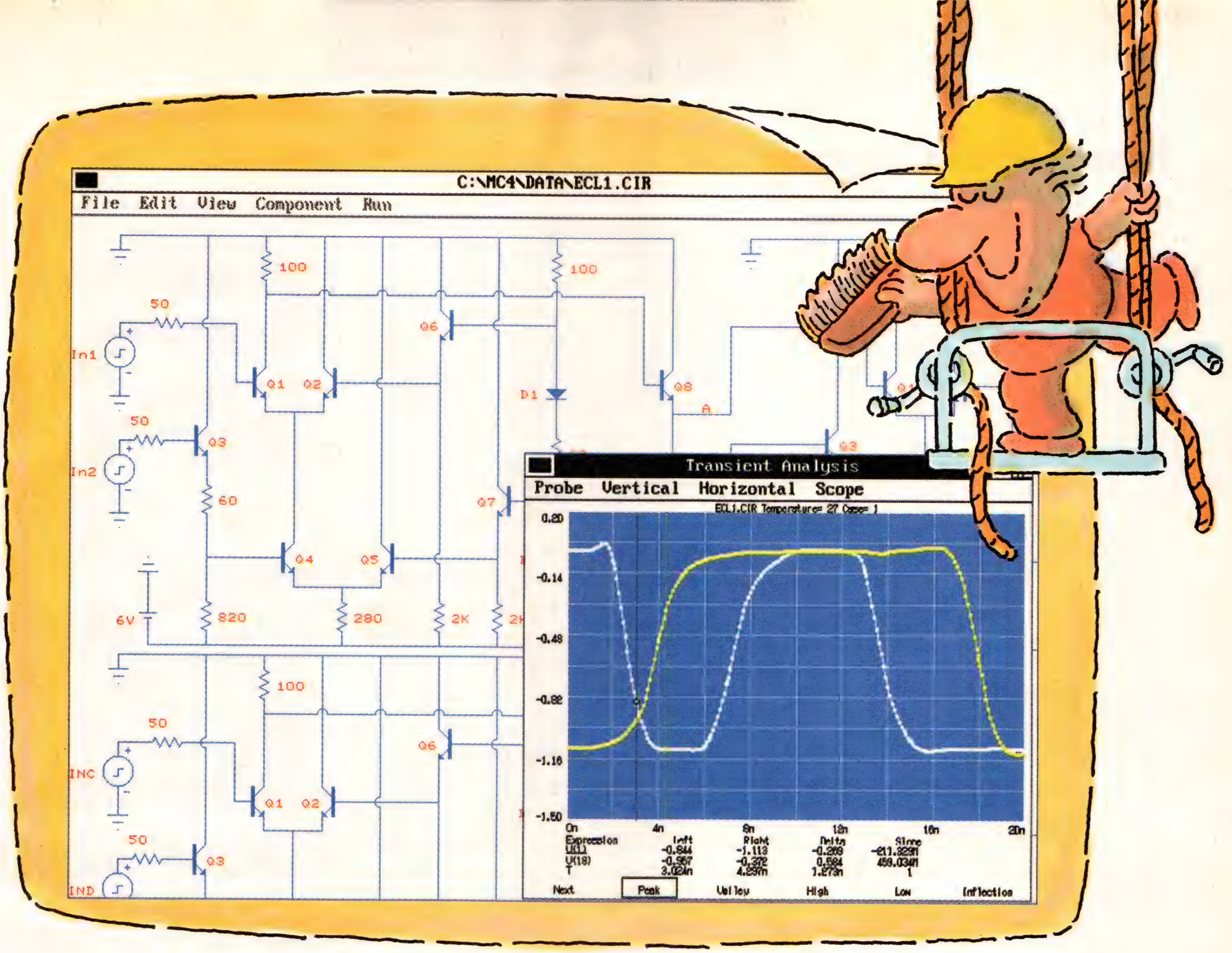


Fig 6—A simple delay model has the inherent shortcoming of only handling reflections (blue trace). The lumped model gives a somewhat better approximation, but still has some inaccuracies (red trace). The distributed model (green trace) can simulate lossy transmission lines in a fraction of the time needed for the lumped model without the spurious oscillations intrinsic to the lumped model (courtesy MicroSim).

Usable models of digital devices may soon be available, however. Following a route analog-device companies began treading several years ago, Intel's IBIS program hopes to convince digital-device companies to give away Spice models of their devices. Digital-IC makers will not be releasing Spice models out of sheer kindness; their customers' management increasingly requires digital engineers to perform a successful Spice simulation before signing off a digital design.

But IC makers have a tricky problem to solve before they can give away Spice models without also giving away the farm. An accurate Spice model can also reveal proprietary design information to the IC makers' competitors. This desire to protect company secrets explains why not all of the analog-device models released so far are 100% complete. For example, some lack noise-simulating capability altogether.

Intel states that the IBIS program is a solution to this confiden-



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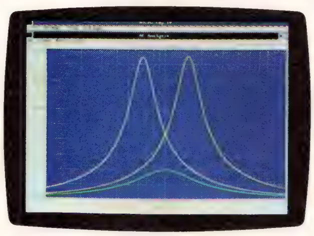

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CIRCLE NO. 142

NOISE VS SENSITIVE CIRCUITS

tiality problem and that IBIS models will provide a usable model for engineers without compromising the device makers' secrets. Details of the IBIS program are still sketchy. Right now, Intel's only example of IBIS models is in its "Pentium Processor Open Design Guide," Chapter 17. For a copy, phone (800) 548-4724 and ask for order number 297267-001 (no charge).

Two transmission-line simulator companies, Integrity Engineering and HyperLynx, already support IBIS.

Transmission-line effects

After getting device models, you need some mechanism for hooking them up that accounts for transmission-line effects if your clock speeds are over ~30 MHz. **Fig 5** shows how to simulate a lossy transmission line using an earlier version of Spice (**Ref 2**). UC Berkeley and Spice vendors have been busily adding these capabilities to Spice. UC Berkeley also includes a handy utility for setting up transmission-line circuits, which can be messy and error-prone to set up manually. (The ZIPfile SR506Z.ZIP, posted on the /freeware Special Interest Group of the EDN Readers' BBS, contains listings for both Spice simulations.)

MicroSim's transmission-line models for its version of Spice, pSpice, handle not only delay and reflections, but also loss and dispersion. A simple delay model has the inherent shortcoming of only handling reflections (blue trace in **Fig 6**). The lumped model gives a somewhat better approximation, but as the red trace in **Fig 6** shows, still has some inaccuracies. The distributed model (green trace in **Fig 6**) can simulate lossy transmission lines in a fraction of the time for the lumped model without the spurious oscillations intrinsic to the lumped model. These models, which

Just how loud can 1/f noise get?

Modeling the low-frequency noise of an op with the appealingly simple equation

$$\text{noise} \propto 1/f$$

suggests an interesting question: Does the noise become infinitely loud when the frequency is zero? Surprisingly, the answer is yes . . . as nearly as we can tell, that is. The key problem with measuring noise at 0 Hz is that such a measurement would take an infinitely long time. Weeks-long measurements of noise at tiny fractions of a hertz do confirm the 1/f model.

Getting help with noise

For free information on combating noise, circle the appropriate numbers on the postage-paid Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you read about their products in EDN.

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MicroSim Corp
Irvine, CA
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Penzar Development
(mixed-signal Spice)
Canoga Park, CA
(818) 594-0363
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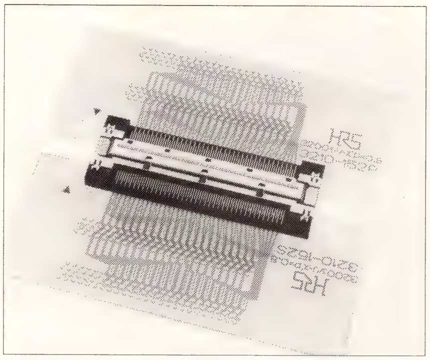
HIGH DENSITY BOARD-TO-BOARD CONNECTOR PROVES IDEAL FOR DOWNSIZING PC's



Developed for downsizing personal computers and workstations, Hirose Electric (U.S.A.) Inc., is providing its 3200 series of high-density interface connectors (board-to-board) with 0.8mm contact spacing and 152 positions.

The new 3200 series connector offers two rows of contacts with 0.8mm contact pitch. Its low profile is only 5.5mm from the PCB with a reliable two point contact pin.

For further information, ***contact the sales department, Hirose Electric (U.S.A.), Inc. (805) 522-7958 or fax (805) 522-3217. For instant fax catalog information: 1-800-879-8071, ask for #8004.***

CIRCLE NO. 69

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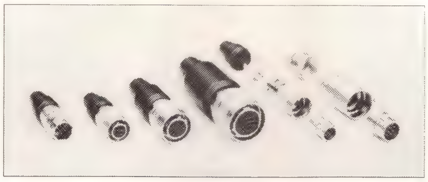

The HR10 Snap-Lok™ circular connector family is designed to be rugged, dependable and to afford rapid, error-free mating and unmating even in the most adverse situations. The HR10 series is provided with three shell sizes (7 mm, 10mm, and 13 mm) and with insert arrangement from 4 to 20 contacts. Crimping type and PC mounting type have been added to the series. In-line receptacle jack is also available, as are crimp or solder contacts.

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CIRCLE NO. 70

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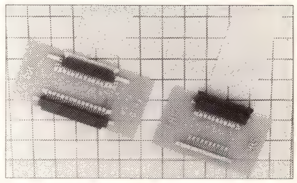

With the ever increasing need for higher density and SMT interconnect systems, Hirose is now providing its FH10A series with 1.00mm (0.039) center line FFC (flexible flat cable) and FPC (flexible printed circuit) zero insertion force (ZIF) SMT connectors.

Available with 6 to 30 pins, Hirose's FH10A series has a miniature profile 3.00mm high. ZIF allows for ease of conductor insertion.

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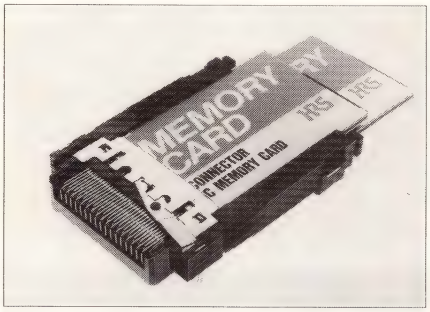
CIRCLE NO. 71

DUAL SLOT MEMORY CARD CONNECTOR SERIES



Hirose Electric has developed the IC6 series of dual slot memory card header connectors which meet the needs of two cards per device, which is especially important to mobile computer designers who need to meet PCMCIA 2.0, and JEIDA Version 4.1 requirements.

The IC6 employs SMT compatible material and accepts Type I or Type II cards for insertion in either slot, while Type III cards (10.5mm thick) can be inserted in the upper slot.

Ejectors are provided for each slot and standoffs are available (either none, or 2.2mm and 5.0mm). Grounding contacts to mate with PCMCIA grounding clips are available. There are two locking lengths (1.6mm = .062" board). The IC6 is offered in a low profile of 11.6mm (two slot height).

For further information, ***contact Hirose Electric (U.S.A.), Inc. (805) 522-7958 or fax (805) 522-3217. For instant fax catalog information: 1-800-879-8071, ask for #8005.***

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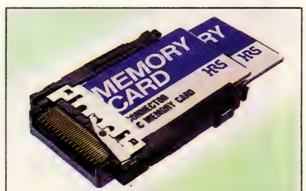
Our 3200 series of shielded I/O connectors is available in 15-positions for PCMCIA applications. These durable connectors meet the PCMCIA I/O requirements for 5000 mating cycles. They are ideal for LAN and FAX/modem applications and will fit in a type I card.

Shown in the window is the IC6 series of dual slot PCMCIA card header connectors for Types I, II and III cards.



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CIRCLE NO. 73

NOISE VS SENSITIVE CIRCUITS

can define resistance and capacitance parameters as general Laplace expressions in the distributed model, also model frequency-dependent effects such as skin effect and dielectric loss.

Simulator designers extending their tools from analog to digital don't have as hard a job as you might think. For example, a handful of postprocessing commands entered into the "calculator" window of Cadence's Analog Artist yields the noise-figure plot in **Fig 7**.

Often, designers working in different realms use different terms for the same thing, as **Table 2** shows. **Fig 8** shows Harris' Fastrack simulator analyzing a low-noise, npn-transistor, UHF circuit. One plot shows the circuit's noise voltage in $V/\sqrt{Hz}$, and the other plot shows the circuit's noise figure in dB. The math for simulating the circuit is exactly the same for both outputs; only the final calculations and formatting differ.

Table 2—Comparison between dynamic-range terms for mid- and high-frequency systems

Mid-frequency	High-frequency
Harmonic distortion	Harmonic distortion
Total harmonic distortion	Total harmonic distortion
Total harmonic distortion plus noise	Signal-to-noise ratio plus distortion
Signal-to-noise ratio	Signal-to-noise ratio without harmonics
Spurious free dynamic range	Spurious free dynamic range
	Intermodulation distortion (IMD)
	Third-order IMD intercept

PC-board layout

Designing systems that have no noise problems doesn't end with circuit design; pc-board layout is an important part of any analog, high-speed digital, or mixed-signal design. Good pc-board layout for noise-sensitive circuits begins at the prototype stage. You must pay just as much attention to supply decoupling, component placement, and signal runs in your prototype as you do in your final product. Never use sockets or digital prototype boards for the sensitive analog portions of your design. Instead, use a double-sided, copper-clad board and hand wire the components.

When you move from prototype to production pc boards, do not let a CAD program lay out your mixed-signal board as if the design were a low-speed digital pc board. Such a layout will no doubt have a pleasing symmetry and rivulets of neatly parallel traces, but the component placement and signal runs will probably be all wrong.

Digital designers can unintentionally let noise gremlins loose in their mixed-signal designs by specifying a switching power supply. Switching supplies can be potent sources of radiated and conducted noise. If you can't afford a linear supply, consider shielding your switcher and filtering its outputs.

Fig 9 shows such a simple filter. The inductors can be no more than simple ferrite beads. The filter's values depend on your circuit and switching supply; values that cancel noise from one supply could resonate with the noise from another

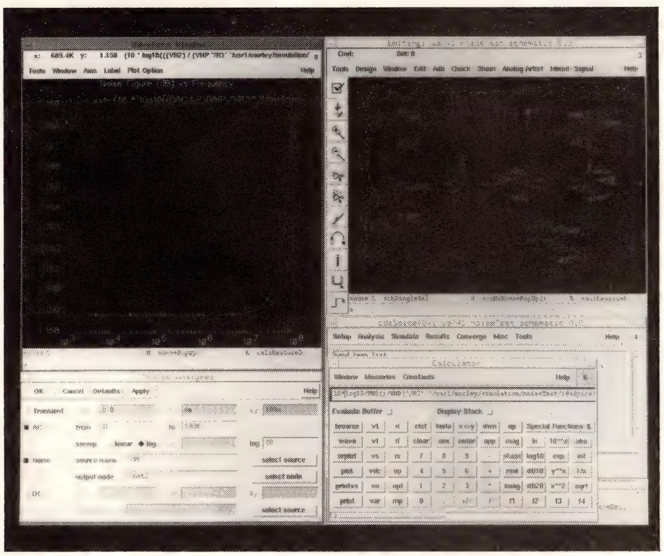

Fig 7—Adapting the output of a simulation run to different designers' needs is often just so much post processing, as the formula for noise in the "calculator" box shows.

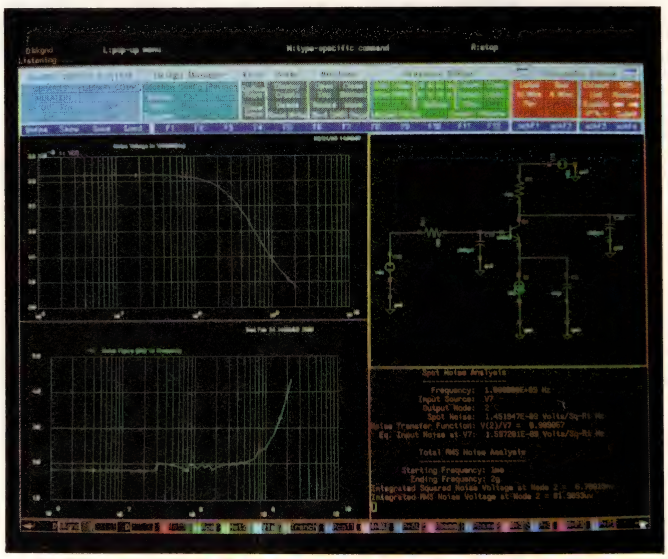

Fig 8—This simulator has formatted the output from one run two ways: as noise voltage for low-frequency designers and noise figure for high-frequency designers.

Supplies for your 3 volt diet

If you're struggling with a 3 volt logic diet, and the lower power consumption and dissipation which it promises, remember the importance of your power source. Because an effective design can so easily be ruined by a hungry, inefficient power supply.

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The new PKE 4210 from Ericsson makes dieting easy. Call us for the full facts.

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CIRCLE NO. 114

Noise vs Sensitive Circuits

supply. Beware of unannounced production changes on the part of your power-supply maker. Insert language in your quote that requires the power-supply maker to notify you of any changes, or you may find that your carefully engineered power-supply filter has suddenly become strangely ineffective.

Digital designers moving up to clock speeds over ~30 MHz can also select digital devices that have small-value series-termination resistors in series with their output lines, a technique first used in dynamic-RAM (DRAM) arrays. **Fig 10(a)** shows the output of an FCT-T series gate having no series resistor. Note the 1V ground bounce and 0.6V reflection. An equivalent gate having a ~25µ internal series-termination resistor produces the output in **Fig 10(b)**. EDN

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Acknowledgment

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You can reach Charles Small at (617) 558-4556.

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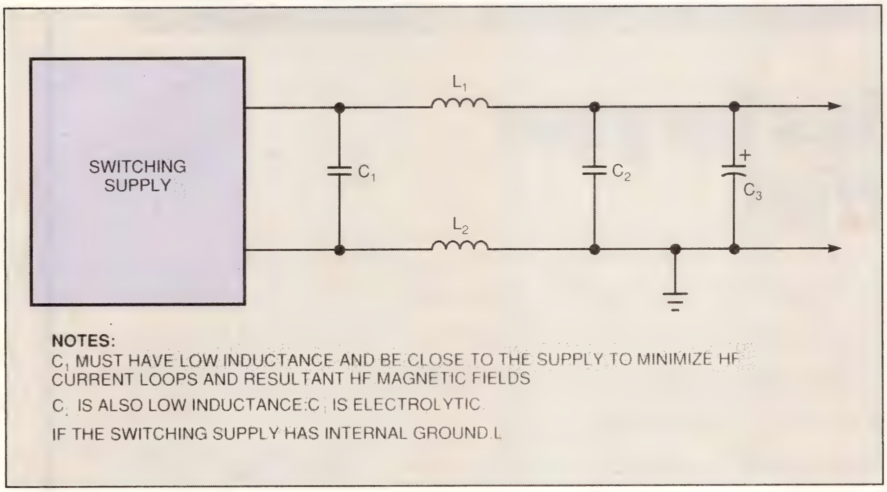

Fig 9—If you can't afford a linear power supply, consider shielding your switcher and using a simple filter to clean up its outputs.

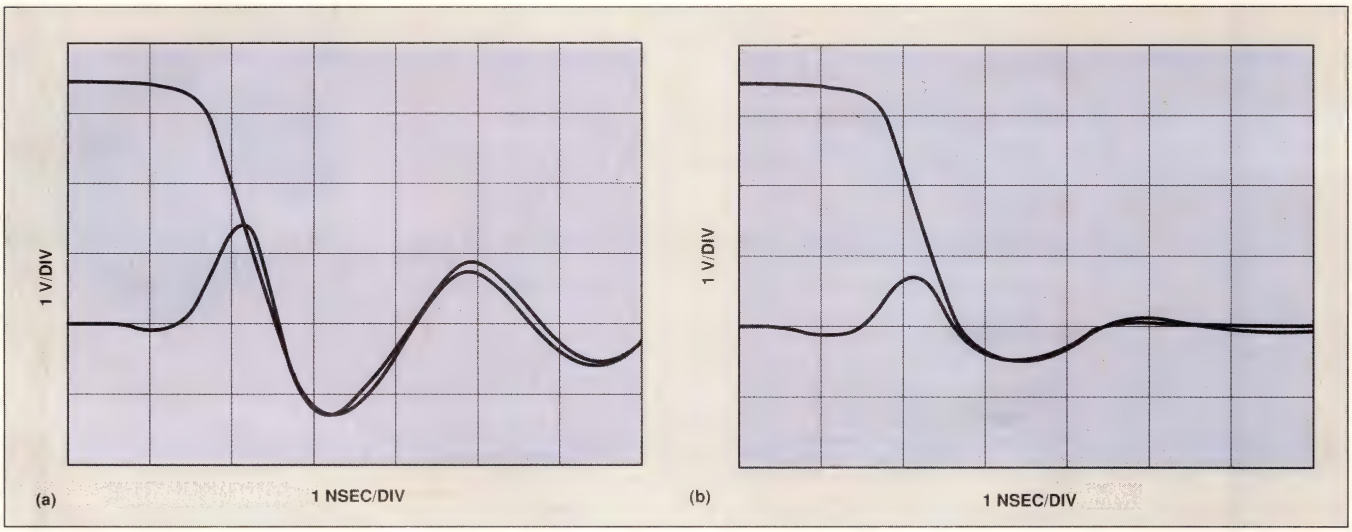

Fig 10—Without series-terminating resistors, a high-speed digital gate generated a 1V ground bounce, followed by a significant 0.6V reflection (a). In (b), the resistor version of the same gate is much better behaved (courtesy Quality Semiconductor).

Op-amp selection minimizes impact of single-supply design

Walt Jung and James Wong, Analog Devices Inc

This 2-part series focuses on designing using devices and techniques that extract the maximum benefit from single power supplies. Part 1 discusses limitations and problems designers encounter when building systems from single-supply devices. Part 2 will discuss a variety of circuits for single-supply applications.

As system designers begin using single-supply power not just in digital circuits but also in analog circuits, performance often suffers. Yet, the demand for higher performance continues unabated. When designing a single-supply application, you should employ amplifiers expressly designed for the job. Among the performance specs you'll enhance are the supply-power and operating ranges, dynamic range, and input and output ranges. You'll also achieve more linear operation overall.

Designer's guide to single-supply analog design Part 1

When most op amps operate from ±15V supplies, they accept an ample input common-mode (CM) range and provide a wide output range—both typically being ±10V or more. Single-supply systems, on the other hand, often handle much smaller voltage ranges: 12V down to 5, 3, or even 1.5V. At these voltages, most available dual-supply op amps simply cease to function; a few will operate but with performance degradation. In general, your choice of single-supply amplifiers is much more limited than dual-supply amplifiers.

General-purpose amplifiers such as 741s and 1558s, as well as most FET-input amplifiers, can operate from supplies as low as ±5V, or 10V total. Precision-amplifier families such as the OP-07 and OP-27 do not work below 5V. Some selected family types may be useful for some regions of this voltage spectrum; for example the OP-97 proves useful down to ±2.25V (4.5V). Typically however, only amplifiers specifically designed for single-supply or low-voltage operation can function without major performance compromises below 10V total.

Amplifiers designed for ±15V operation typically require 2 to 5V of headroom, with respect to both supply rails, at both inputs and the output. Even the more flexible dual-supply amplifiers approach only within 1V or so of the rails.

In single-supply applications, this need for headroom limits linear operation over wide signal swings. These limitations are most acute at lower supply voltages. For this reason, single-supply amplifiers' input stages usually remain linear even when the common-mode voltage applied is right at the negative rail (ground) or even slightly below (~ −200 mV). Op-amp input stages that operate this way are pnp bipolars, CMOS or PMOS types, and N-channel JFET types.

Obviously, devices with these various input stages will have differing input-bias currents, noise voltage and currents, and offset voltage and drift. Spec sheets delineate these characteristics, but a subtle (and potentially important) behavior for a given device is how it reacts to common-mode stresses.

SINGLE-SUPPLY ANALOG DESIGN

Overdriving many amplifiers below the negative rail (pnp inputs in particular) will usually cause a nondestructive output-phase reversal. The overdriving may not actually damage the device if the input-fault current is limited, but the circuitry around the amplifier may react violently. If the circuitry is a polarity-sensitive servo, for example, it may lock up or oscillate.

Few single-supply amplifiers have internal protection against overdrive. Fortunately, preventing overdrive is rather easy. Simply clamp the input voltage to no more than 300 mV below the negative rail with a low-threshold Schottky diode **(Ref 1)**.

You must protect CMOS- and PMOS-input-stage amplifiers more carefully because exceeding their supply rails can trigger a parasitic SCR within the device—with destruction possible. As with any CMOS device, you should keep possible transients in mind and follow data-sheet recommendations.

At the positive end of input-CM range, some devices can operate to within 1V of the rail; others may need 1.5V of headroom. Generally, overdriving an op amp's common-mode inputs above the positive rail causes nonlinearity (as opposed to phase reversal). Again, do not drive CMOS- or PMOS-input devices beyond the positive rail.

With the exception of rail-to-rail output-stage devices, most op amps can swing only to within 1 to 2V of the positive rail. Consequently, when these devices operate from supplies of 5V or less, output swing is greatly reduced. Even if the input's noise floor were to remain constant (which it seldom does), the S/N ratio and dynamic range suffer for devices operating from low voltages. The **box,** "Output-stage swing makes or breaks single-supply operation," covers some salient points on output-stage designs for single-supply low-power amplifiers.

Ultralow quiescent current drain

Another fundamental reason for using single-supply designs is to conserve power. For this reason, most single-supply op amps draw low standby current. Very-low-current designs involve fundamental tradeoffs. In general, low-current designs tend to sacrifice bandwidth, slew rate, and input noise voltage.

Standby-current drain per amplifier channel can often make or break a device when a system's power consumption is critical. The industry has no standard definition of "low power." We suggest that devices drawing quiescent currents of ≤1 mA/channel are low power, and those drawing ≤100μA/channel are "micropower." Most of the devices discussed in Part 2 of this series meet one of these definitions.

Given a requirement for low-power designs, engineers are forced to face not just slower speeds but also bandwidth restrictions arising from higher circuit impedances.

Noise versus supply current is an issue where tradeoffs are likely. **Table 1** lists three representative op amps and shows that lower noise is attainable at the price of increased current.

Bandwidth, too, is another area where tradeoffs are likely, as **Table 2** shows. The dual amplifiers in **Table 2** bracket the industry-standard 324 and 358, which feature 500-μA/channel current drain, 1-MHz bandwidth, and a 0.6V/μsec slew rate. Greater speed also comes at the price of increased current.

Assigning ground is a task that can become quite important in single-supply, ac-coupled op-amp circuits.

Table 1—Noise-vs-supply-current tradeoffs

Device	Noise (nV/√Hz)	Supply current/channel
OP-295	51	160 μA
AD820/AD822	12.5	750 μA
OP-213	6	1.45 mA

Table 2—Current-vs-bandwidth tradeoffs

Device	Current drain (μA/channel)	Bandwidth	Slew rate (V/μsec)
OP-295	160	75 kHz	0.03
AD822	750	2 MHz	3.5
324/358	500	1 MHz	0.6

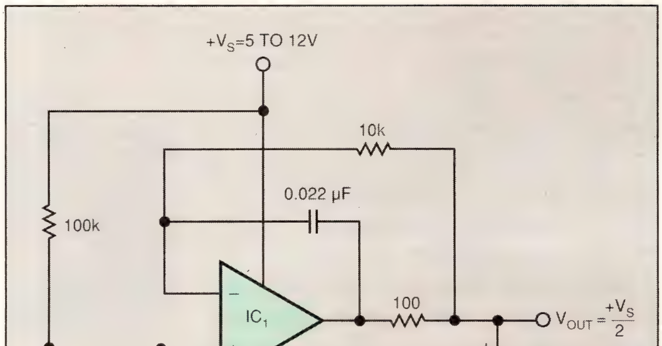

Fig 1—You can make your "false" or "pseudo" ground any value desired. When dynamic currents are high, use this simple op-amp follower.

Output-stage swing makes or breaks single-supply operation

Not all single-supply amplifiers' outputs can swing to the negative rail (ground). Some may swing to within a diode drop (0.6V); others may swing within a few tens of millivolts. Only a very few swing to less than 1 mV from the negative rail.

To understand which op amp functions best for output-swing-critical applications, you must have some detailed knowledge of output stages. **Fig A** shows a sampling of output-stage topologies used in single-supply op amps.

The bipolar complementary emitter-follower stage in **Fig A(a)** is only active to within a diode drop of each rail, at best. This stage may or may not use a Darlington for transistor Q_1 but usually has a single pnp for Q_2. This output stage cannot swing to ground without outside help, such as the added resistor $R_{PULLDOWN}$. When used, this resistor allows output linearity to ground for source-type loads only. It also raises overall dissipation for sustained high-level outputs. Amplifiers with this type of output stage can be useful for single-supply applications, but you must carefully apply them to optimize all tradeoffs.

The NMOS bipolar emitter-follower common-source output stage in **Fig A(b)** has, by nature, an asymmetrical voltage swing. However, the stage features low saturation voltages to ground because of the NMOS pulldown transistor N_1. Saturation voltage to the positive rail is about 1V (or more). The advantage of this stage is that the NMOS pulldown transistor can drive current-sink loads to within a few millivolts of ground, which enhances linearity in many single-supply applications.

The CMOS stage of **Fig A(c)** is, by definition, fully complementary and offers a resistive connection to the supply rail for a high or low output, that is, rail to rail. With appropriate low-R_{ON} transistors for P_1 and N_1, saturation drops to either rail can be a millivolt or less at low currents. Because this stage is inherently Class A, the amplifier design must carefully control the static currents in P_1 and N_1 for low quiescent current. For output currents of a few milliamps, this type of output stage is effective and quite versatile because of its rail-to-rail nature.

The complementary-bipolar common-emitter stage of **Fig A(d)** is another rail-to-rail output stage. Saturation drops to the rails range from a few millivolts to hundreds of millivolts over current ranges up to 20 mA. Like the CMOS rail-to-rail output stage, this bipolar counterpart is both effective and versatile, but avoiding punitive tradeoffs in power is critical to the design of the bipolar stage.

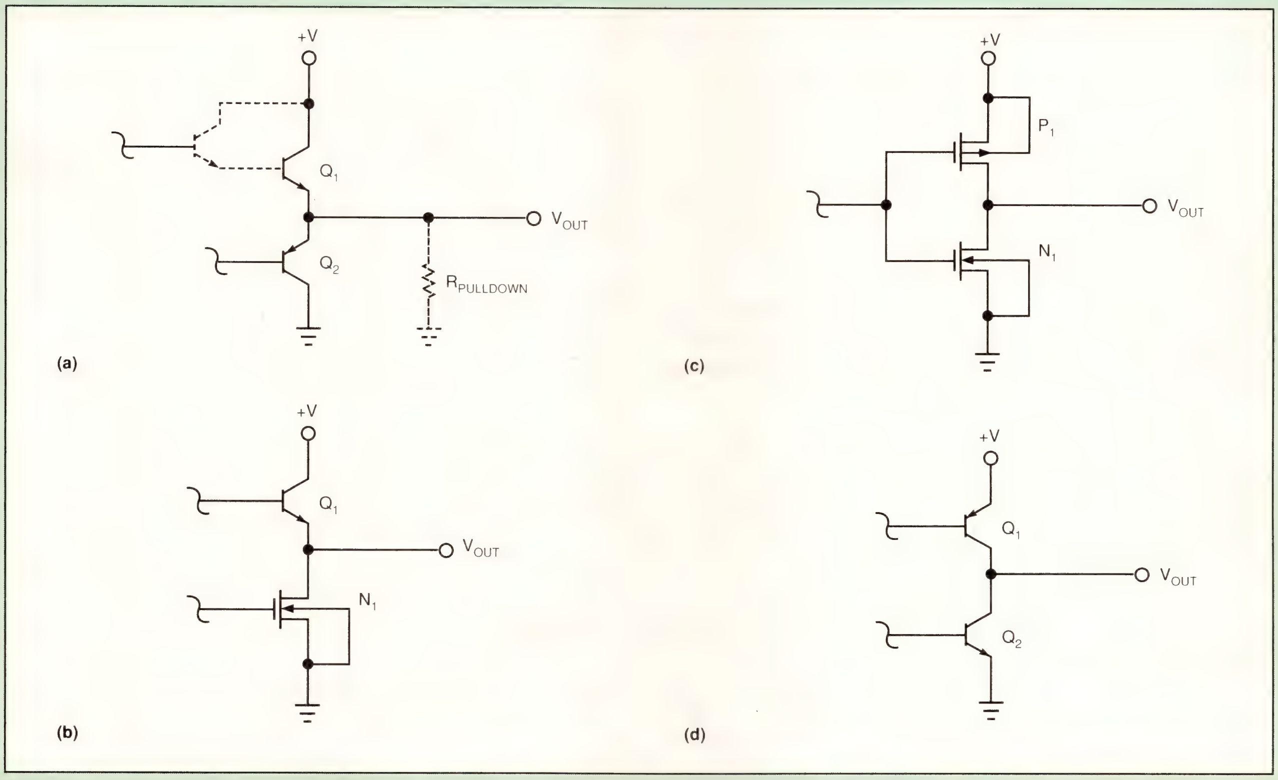

Fig A—Among this sampling of output-stage topologies used in single-supply op amps, the bipolar complementary emitter-follower stage (a) is active only to within a diode drop of each rail at best. The bipolar emitter-follower, NMOS common-source output stage (b) has, by nature, an asymmetrical voltage swing. The CMOS stage (c) is, by definition, fully complementary. The complementary-bipolar common-emitter stage (d) is another rail-to-rail output stage.

You can make this "false"or "pseudo" ground anything you desire. The best choice depends on the individual application, but maximum amplifier flexibility helps make signal referencing less problematic, particularly if the design has substantial dynamic current into an elevated ground.

Possible choices for false ground range from simple ac-bypassed resistive dividers to fully buffered op-amp follower stages for the lowest wideband dynamic impedance. A well-bypassed, noise-free divider is suitable for high-impedance loads when the dynamic current is low. When dynamic currents are high, use a simple op-amp follower such as the one in **Fig 1**. This circuit works with a wide range of supplies to produce a low-noise output of $V_{SUPPLY}/2$. Your choice of IC_1 determines the circuit's standby current.

If you need a precise "pseudo-ground" voltage, use a reference IC that can source and sink current, such as that in **Fig 2**. Operating from a 5V supply, this circuit can handle load currents both into and from the 2.5V source. Low-ESR (equivalent series resistance) bypass capacitors help keep the circuit's ac impedance low.

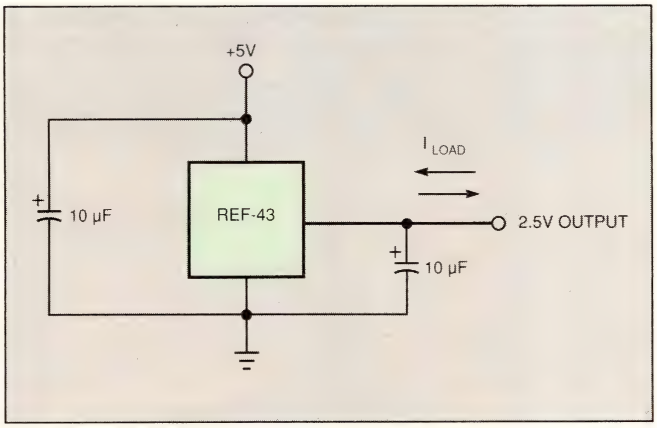

Fig 2—Use a reference IC that can source and sink current if you need a precise "pseudo-ground" voltage. This circuit can handle load currents both into and from the 2.5V source. Low-ESR bypass capacitors help keep the circuit's ac impedance low.

Power-supply noise, if not dealt with correctly, can shred even the best paper design. Low-power circuits tend to have poorer supply rejection, and the noise from commonly used 5V digital supplies is nearly worst case. Simple power-line filters may not be adequate for high-performance analog stages. Although a common analog and digital supply may be attractive for size and cost reasons (or simply decreed by your boss), you should avoid a common supply if at all possible.

First, power taken from the middle of a logic layout contains huge amounts of high-frequency noise—100 mV or more. Worse yet, logic supplies are typically switching types, which have large output spikes. Thus, using a separate, linear-mode, low-noise supply for the sensitive analog circuits is better whenever possible.

If you must use a 5V logic supply, isolation and circuit partitioning as well as optimized decoupling and filtering can help greatly **(Ref 1)**. First, make sure that you tap the supply for analog power right at the supply terminals—not from the logic stages. This routing avoids the voltage drops of the logic-supply runs and allows maximum supply regulation.

Bypass capacitors alone are usually not adequate for filtering switch-mode glitches, so you need to take additional steps. **Fig 3** shows a more effective technique **(Ref 2)**. This balanced LC filter comprises two high-frequency inductors—each made from a 3-turn, toroidal ferrite bead—and a large, composite output capacitor. The capacitors should be low-ESR switching types for best performance. The filter as shown suppresses glitch noise by 40 dB or more.

Even given a device that has a wide output swing,

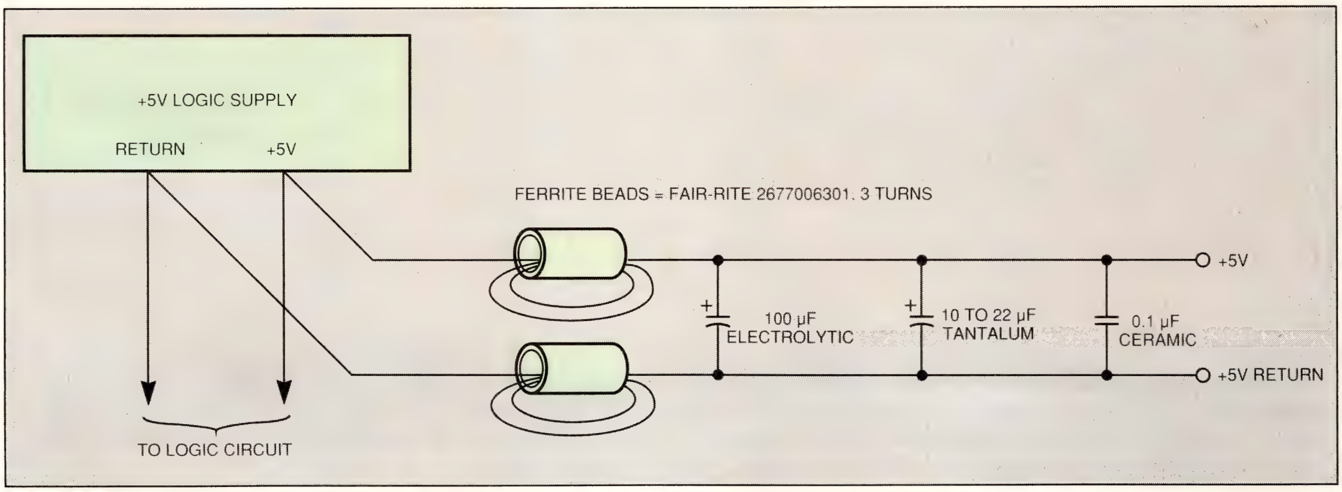

Fig 3—This balanced LC filter suppresses glitch noise by 40 dB or more.

the application's configuration can limit the swing. For example, the 2 op-amp instrumentation amplifier in **Fig 4** normally uses dual supplies. But in this case, the instrumentation amplifier uses a single supply and has a gain of approximately 100.

At first glance, this instrumentation amp will faithfully amplify a 10-mV differential input to 1V at V_{OUT} with a low common-mode voltage. However, a close examination proves otherwise. Amplifier IC_1's output must be a *negative* 94 mV to satisfy the loop's requirements and produce 1V at the output. Obviously, IC_1 cannot produce a negative output from a single supply. Indeed, if the circuit attempts such operation, IC_1 saturates, and V_{OUT} becomes nonlinear.

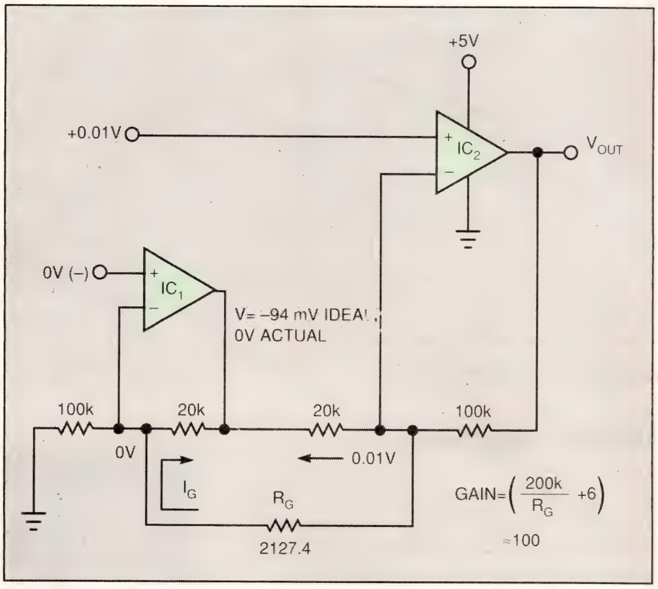

Fig 4—This 2 op-amp instrumentation amplifier normally uses dual supplies. Using a single supply constrains the design's common-mode range.

As it turns out, this input-CM limitation is a function of the instrumentation amp's gain as well as the output swing of the op amps within it. Therefore, low negative-V_{SAT} or rail-to-rail output-stage op amps help improve common-mode handling. In **Fig 4**'s example, the worst-case minimum-CM voltage is 0.4V (assuming a 5V output swing and each op amp swinging to within 100 μV of each rail). However, op amps that cannot swing to 0V will have a worse input CM-voltage minimum. The point here is that even though an op amp could be designed for single-supply operation, your configuration can still constrain the op amp.

Despite its basic limitations, this topology can still be useful if you apply it carefully. For example, **Fig 5** shows an accurate strain-gage bridge amplifier circuit in which the bridge and amplifier are powered from 5V. The amplifier produces linear outputs to as low as 600 μV from ground. In this case, the bridge itself supplies the 2V common-mode bias, which keeps the op amps in the middle of their common-mode range. Driving the bridge with a low-noise 4V supply further minimizes noise. (Part 2 of this series details a low-noise 4V supply.)

Fig 6 shows another instrumentation-amplifier approach. Compared with the **Fig 4** circuit, the **Fig 6** circuit's primary advantage is that it doesn't exhibit extreme common-mode limitations. Also, the topology in **Fig 6** switches divider taps for gain changes, so moderate switch resistances (10 to 100Ω) do not cause

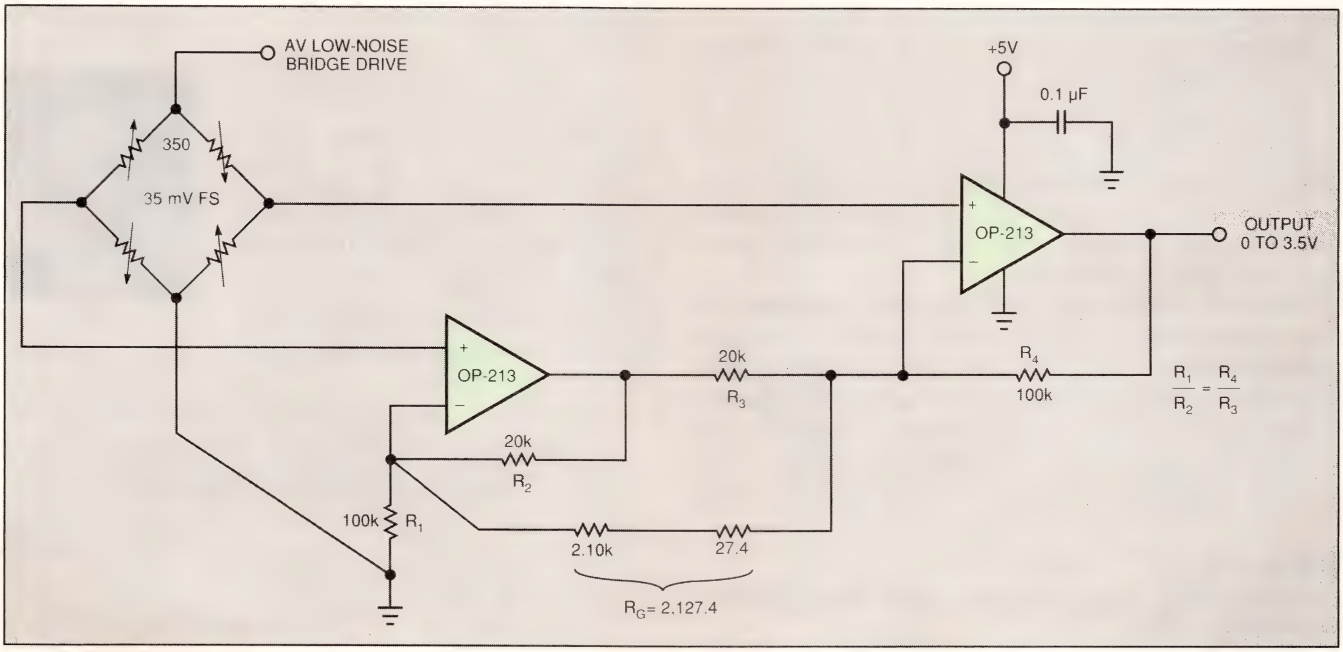

Fig 5—This accurate strain-gage bridge amplifier operates from 5V and produces linear outputs to as low as 600 μV from ground.

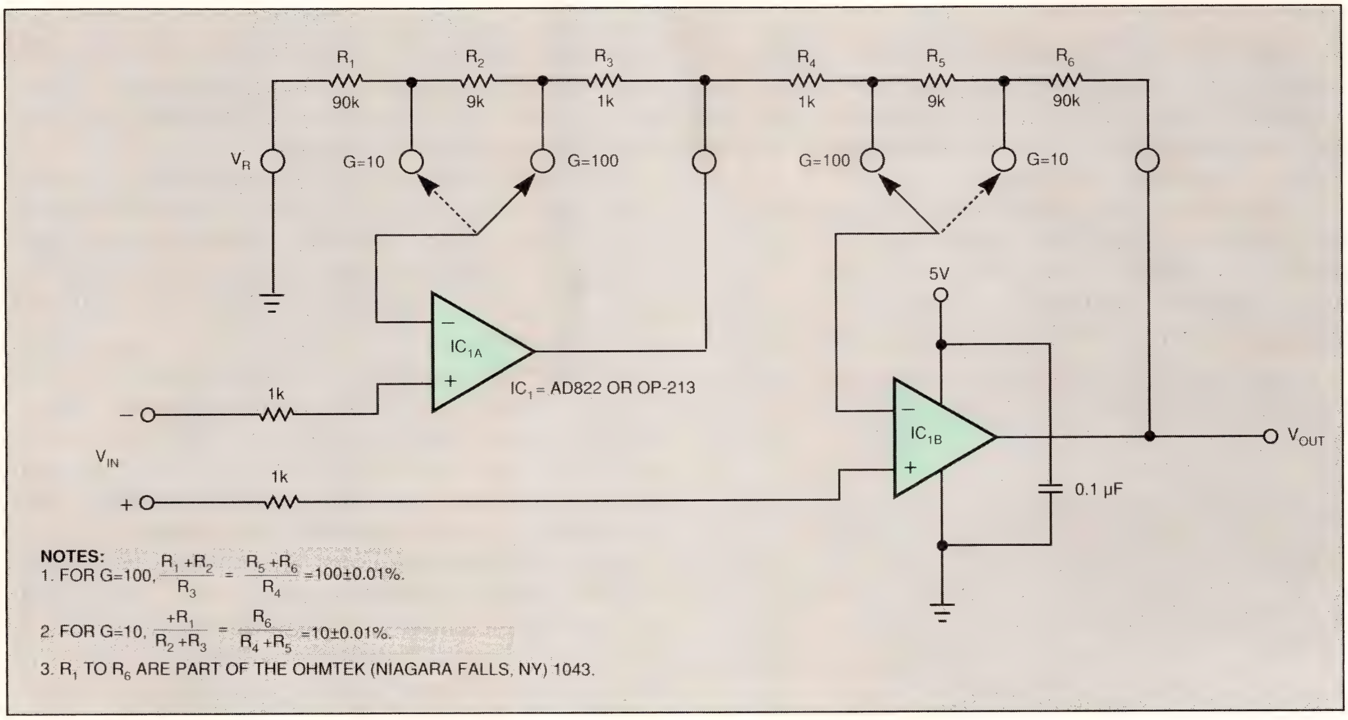

Fig 6—This instrumentation amplifier shrugs off switch resistances, enabling you to switch gains.

major errors. You can easily set the circuit's gain with jumpers or dpdt CMOS switches. However, adding the same gain-setting switches in series with R_G in **Fig 4** would produce serious errors.

In **Fig 6,** amplifier IC_{1A} is a follower for signals at terminal $-V_{IN}$, and IC_{1B} is a follower for signals at $+V_{IN}$ and an inverter for signals at its negative input. The linear subtraction of CM signals and amplification of differential signals provides the circuit with a precise gain that you can vary between 10 and 100.

The performance keys to this circuit are the resistor network and the amplifier. For best performance with premium amplifiers, the resistor network should have a ratio-match specification of 0.1% minimum with 0.01% as a goal. For ideal amplifiers and 0.01%-match gain resistors, the common-mode error at the output will be on the order of −100 and −120 dB for gains of 10 and 100, respectively.

You must observe the common-mode limitations of the configuration if you use a single supply. The circuit produces a V_{OUT} that's referred to the potential applied to the resistor network's V_R pin. This ground assignment implies that if you want the circuit to exhibit high linearity for even small V_{IN} difference voltages, the op amps should be able to swing close to ground. EDN

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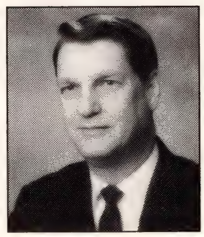
Authors' biographies



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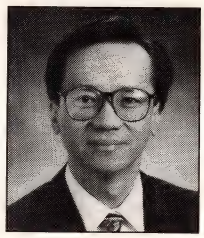

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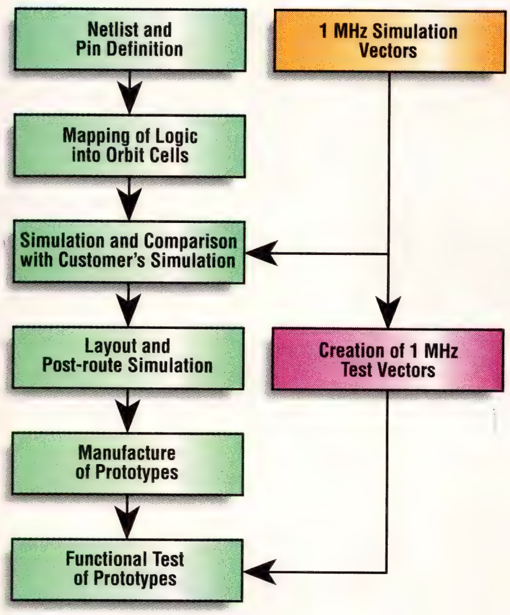

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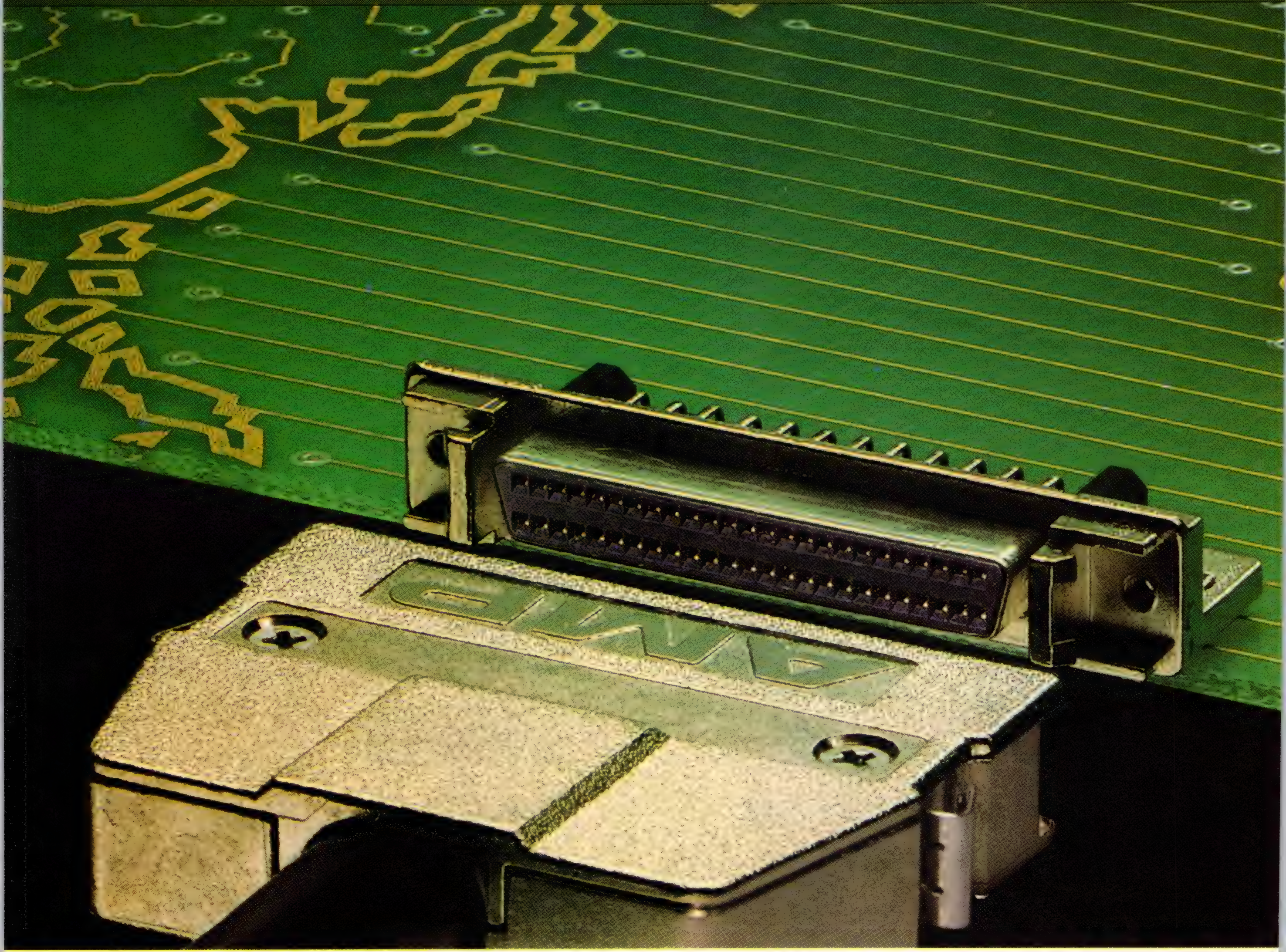

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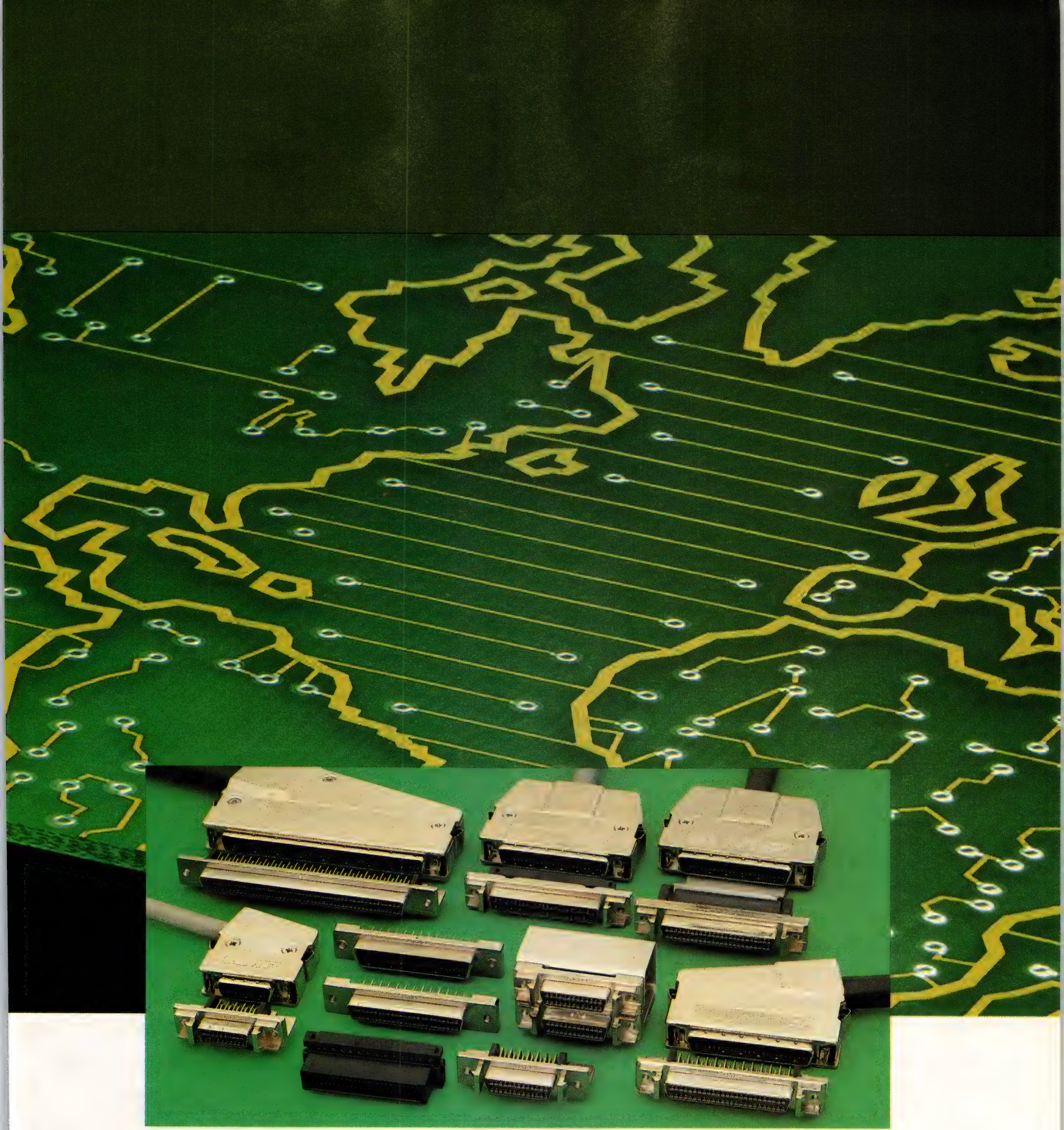

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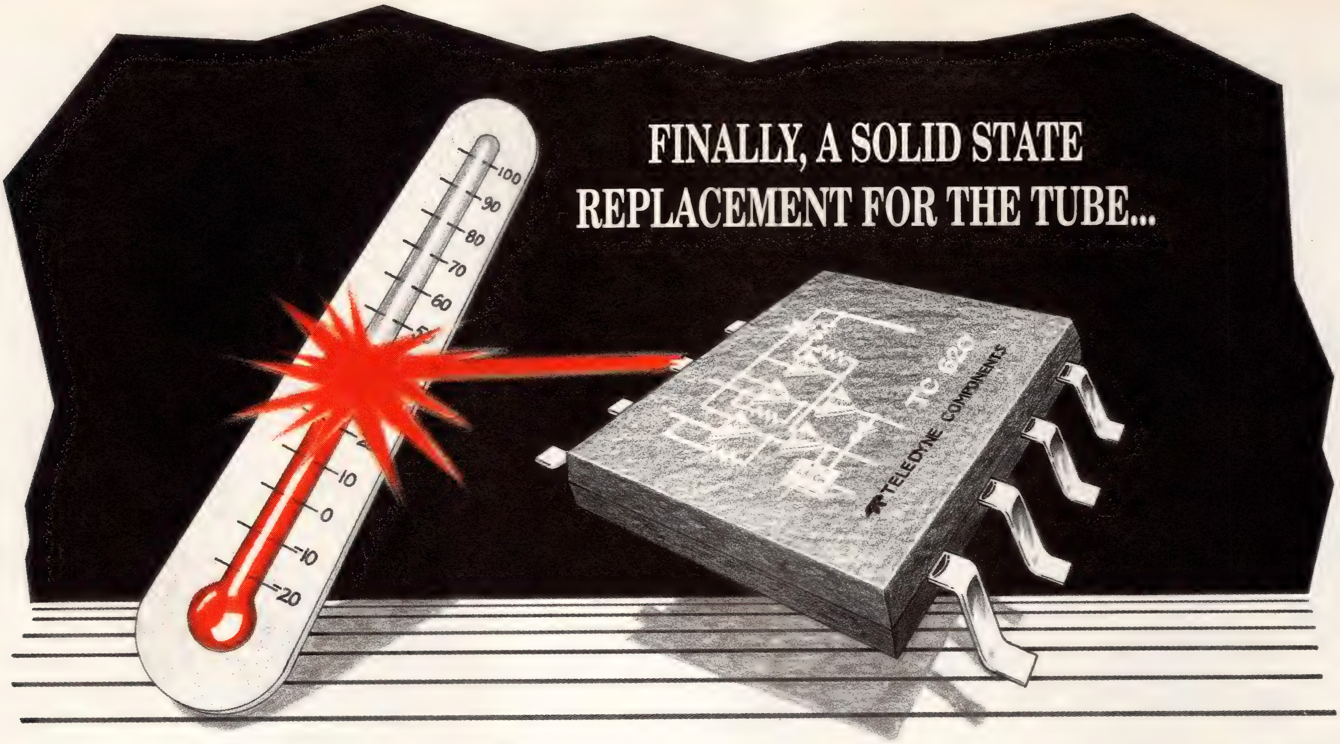

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CIRCLE NO. 143

Measuring transient voltages between separate ground points

Art Porter, Hewlett-Packard Co

How many times have your circuits been bitten by ground loops or induced voltages on the system ground plane? Knowing how to make scope measurements of ground potentials can put your circuit on a fast road to recovery.

Textbooks apply the phrase "circuit ground" to a reference potential from which you can measure relative voltages. In practice, however, no two points on a circuit's ground plane are exactly at the same potential, and they generally exhibit a nonzero impedance between them. Overlooking this fact in the presence of the transient ground currents common in today's high-speed digital circuits can lead to circuit problems that are difficult to analyze and troubleshoot. Three scope methods offer pros and cons to characterize these potential differences by measuring the voltage between separate ground points.

Digital circuits respond to the potential difference between an input signal and the ground potential measured on the die. If there is sufficient inductance between the die and the package pins, the transient voltage between the die's ground potential and the ground potential at the pin can be significant. The notorious ground-bounce effect in high-speed CMOS circuits is a good example.

The problem is further exacerbated by inductance in the trace that connects the ground pin to a ground plane on the pc board (**Fig 1**). An additional potential difference is due to the inductance of the ground return between the pc board's ground plane and the power supply's ground. Essentially every ground conductor has inductance, and rapidly changing ground currents will induce a transient voltage in the conductor according to $E_{ind} = L \times di/dt$.

Suppose you're scratching your head because a gate or a flip-flop changes state when there is no appropriate change of input signal. The enigma may be resolved if you consider the IC's ground as one of the input signals. Remember the IC responds to the potential difference between an input pin and its ground pin; voltage changes on either pin affect the circuit the same way. To ascertain if a glitch or metastable state is caused by an induced ground potential, you need to be able to measure the voltage difference between two separate points on the ground plane.

To measure the voltage across a low-resistance path when there is no absolute ground reference, you must make a differential measurement between the two points. One method is to use a dual-channel oscilloscope and two probes of the same type. You connect one probe to one point on the ground path in question and

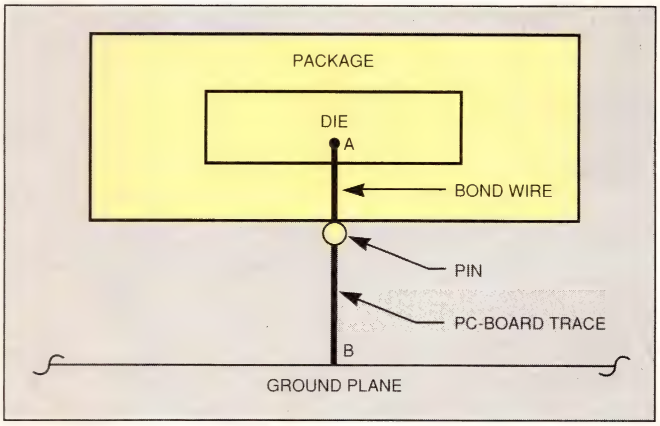


Fig 1—The ground potential at point A on a die can be different from the potential at point B on a pc board's ground plane. The inductance of the bond wire from the die to the package pin and the inductance of the pc-board trace from the pin to the ground plane induces a transient voltage when there are rapidly changing ground currents.

the other probe to another point on the ground plane. You then subtract the signals for each channel using the scope's A − B feature.

To make reliable measurements, you must minimize the time skew between each channel, including the probes. To de-skew the probes, you can follow the recommended procedures in the operator's manual, but generally only digitizing oscilloscopes let you adjust time skew between channels. If you use an analog oscilloscope, you must use probes that have well-matched time delays. The Tektronix Model P6135A matched pairs of probes are good examples.

The gains of the two channels and the two probes must also match. Most digitizing scopes have a probe attenuation factor that lets you match the probe and channel gains. You connect both probes to a common signal, set the scope for A − B operation, and adjust the probe attenuation factor on either channel for minimum deflection on the display. On an analog scope, you can use the vertical sensitivity vernier on either channel to balance the gains. Some digitizing scopes have a continuously variable vertical sensitivity, which lets you match the gains.

If you use 1- or 10-MΩ style probes that need to be frequency compensated, be sure to carefully adjust the compensation on each probe. Any mismatch in the probe's compensation can lead to severe degradation of the common-mode rejection at high frequencies. Connect the probe grounds using a short wire and then connect the center of this wire to a ground point in the system under test.

Because the system ground point can affect the test results, you should choose it with some care. Ideally, the system ground point should not experience a current transient that coincides with the induced voltage transient you are trying to measure. A sheet-metal ground or a board-mounting screw near the measurement point is often a good choice. It's also a good idea to intertwine the two probe cables to minimize electromagnetic coupling to the probe shields (**Fig 2**).

A low-resistance divider probe, such as the HP54006A or the Tektronix P6150, is generally the best probe for making dual-channel differential measurements. The HP54006A probe has a flat frequency response and a bandwidth of 6 GHz. Although the divider probe has a minimum input impedance of 450Ω, resistive loading is negligible because the measurement is being performed on a low-impedance circuit.

There are some inherent inaccuracies in dual-channel measurements, but a few procedures can help you minimize them. One useful technique to evaluate errors caused by ground loops or induced transient voltages at the system ground point is to short the tips of the probes together and disconnect them from the system under test. Observe the scope to see if there are any deflections on the display. If so, move the system ground to another point and try to find a point that minimizes the deflection on the display. In some in-

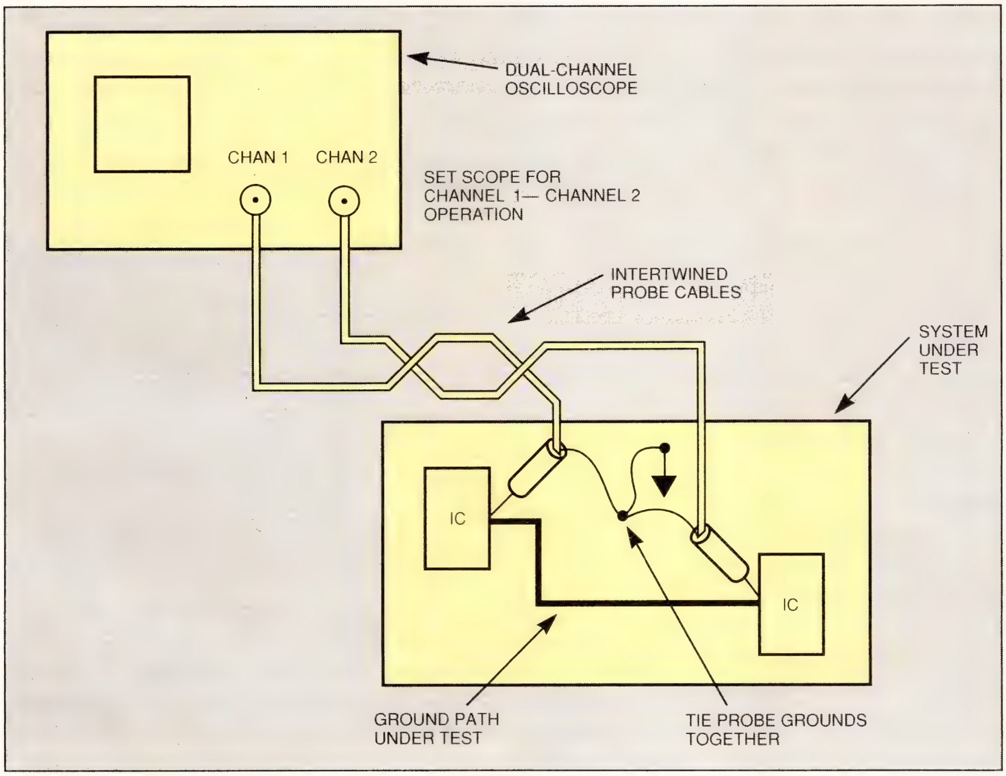


Fig 2—When using a dual-channel scope, connect the two scope ground probes and connect a short wire at the center point to a convenient ground in the system under test. Intertwining the probe cables minimizes electromagnetic pickup.

stances, it may be best not to connect the probe shields to the system ground point. The probe tips must be shorted together to determine this, however.

Other potential sources for measurement error are ground loops formed by the probe shields and the scope ground (**Fig 3**). All ground loops are susceptible to pickup voltages caused by circulating electromagnetic fields. If you use 1- or 10-MΩ compensation-type probes, the input capacitance from the probe tips to the shield and the scope's input-channel capacitance creates ac ground loops. You can minimize the susceptibility of these loops to electromagnetic pickup by intertwining the probes together.

During measurement, each probe is subject to complex electromagnetic and electrostatic fields. Because the two tips are at different locations, the field coupling is different. The signal you observe on the display is not only the actual voltage difference between the measured points, but also the difference in the electromagnetic and electrostatic coupling at the probe tips.

Inaccuracies caused by coupling differences are hard to evaluate and difficult to control, but usually are small enough to ignore. You can test for this coupling effect by moving the probe cables around and observing changes in the scope display. The further apart the measurement points are, the more pronounced the problem is. Another difficulty can arise when the scope can't trigger on the difference signal. Usually triggering the scope on one of the signal channels overcomes this difficulty.

A differential probe, such as the HP 1141A, gives you a second method for making differential voltage measurements. Differential probes provide high sensitivity and excellent common-mode rejection for frequencies as high as 100 MHz. In addition, differential probes eliminate the concern of having two probe shields forming a large loop. You don't have to frequency compensate, time de-skew, or match the gains when using differential probes. Thereby you eliminate these sources for error. Differential probes also let you trigger the scope on the differential signal.

The differential-probe method presents some other difficulties, however. For one, the probe tips on a differential probe are physically close together. If you must make a differential measurement at two points that aren't close together, you must extend the lead lengths of the probes, which adds significant inductance or capacitance. Extending the lead lengths increases the size of the loop that is subject to electromagnetic pickup.

The bandwidth of a differential probe is considerably less than that of a resistive divider probe. For example, the HP 1141A bandwidth is 200 MHz, compared to the 6-GHz bandwidth for the HP 54006A divider probes. You still must determine where or whether to connect the differential probe's ground to the system under test. Similar to the dual-channel method, you must short the inputs of the probe together and determine the optimum grounding point by minimizing the residual signal on the display.

If you have the luxury of owning a digital-storage scope, a third method for making differential measurements is often the most accurate. This method uses only one probe to store digitized data from two points into waveform memory and then perform waveform mathematics to calculate a difference waveform. The procedure is:

1. Measure the waveform at one point and store this data into waveform memory.

2. Measure the waveform at the other point using the same probe and the same scope channel. Don't move the probe's ground connection to the system under test. Store the data into another portion of waveform memory.

3. Use the scope's waveform math capability to subtract the data for the two waveforms stored in memory. The scope will automatically calculate the difference and display the waveform.

If you use the third method, you should adhere to the same precautions concerning the probe shield's connection to a system ground point as in the first two methods.

There are several reasons why the third method is more accurate than the other two. For one, you use

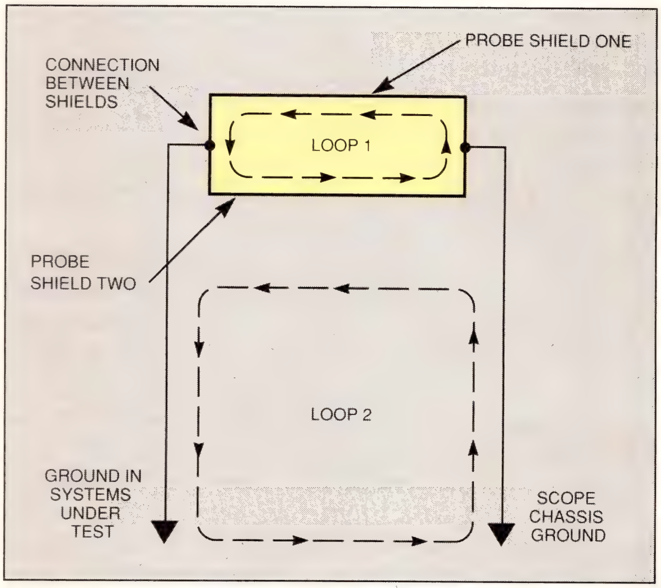


Fig 3—In a dual-channel measurement, the two probe shields form a loop, which can pick up induced currents caused by electromagnetic fields. The connections of the probe shields to the scope-chassis ground and to the ground in the system under test form an additional loop that is susceptible to pickup.

the same probe and scope channel for collecting data from two points. Therefore, there are no errors caused by mismatches in gain, frequency response, or time delays. Because there is only one hook-up from the probe shield to a system ground point, there is no loop formed by two probe shields as there is in the first method mentioned. Also, because the probe tip only measures one point at a time, the ground strip under test doesn't complete a loop, which could pick up induced currents from changing electromagnetic fields.

If you use the third method, you should be aware of a couple of its idiosyncrasies. Unlike the first two methods, the probe loading for the system under test is not balanced. The probe only loads one point at a time. However, because the ground trace under test has a low impedance, the unbalanced load is not a significant problem. In addition, if the physical distance between the two points is long or the system ground point is far removed from the trace under test, the wire connecting the probe shield to the system ground will be long. The inductance of the long lead can cause ringing and electromagnetic pickup. Theoretically, the ringing and pickup should cancel when the scope subtracts the two waveforms. However, the induced voltages caused by the electromagnetic fields surrounding the probe and the ground lead will change when you move the probe. Therefore, the waveforms may not exactly cancel.

Regardless of which method you use, you should be aware of some details that are common to any circuit measurements. Anytime you make a measurement on a circuit, the electrical characteristics of the measuring apparatus become part of the system under test. Circuit loading due to the probe's input impedance is an example, but generally is not a factor when the circuit impedance is low. Two immediate concerns, however, are the currents injected by the probes into the circuit under test and changes in the ground-circuit configuration caused by grounding the probes.

The scope probes inject current into the circuit from the electromagnetic fields surrounding the probes. Because the ground path under test is a current path between the probe tips, the fields induce currents into the path under test. You can minimize the induced currents by using a differential probe as described in the second method or eliminate the current path by using one probe as described in the third method. In addition, if there is a connection between the scope chassis and the ground for the system under test, ambient electromagnetic fields can induce currents in this ground path.

Another reason for current injection is a potential difference that may exist between the scope chassis and the ground for the system under test. Potential difference causes a current to flow between the scope and the system under test through the probe shields and the probe's ground wire. In addition, some current may also flow through the probe tip to the circuit under test. If you use a low-resistance divider probe, such as the HP 54006A, the 450Ω tip resistor limits the current to a negligible value. However, if you use a 1- or 10-MΩ compensation-type probe, current can flow into the circuit through the probe's compensation capacitor, which has a low impedance at high frequencies.

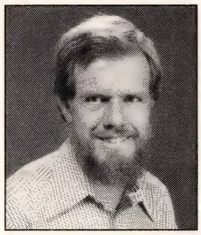
When you connect the scope's ground to the system under test via the probe-shield ground, make sure you don't modify the current path for the ground trace under test. Make sure you don't select a ground point that is directly in the path you are measuring. If the system has separate analog and digital grounds, you should choose an analog ground point when you are measuring a ground potential in the digital section and a digital ground point when measuring a ground potential in the analog section.

Although following these guidelines will increase your confidence in the accuracy of a measurement, it's impossible to set up exact recipes to follow. The best method depends on the particular situation. You should understand the basic principles that cause ground potentials to exist in your specific ground system. As a reality check, you should make measurements using at least two of the methods. If you obtain inconsistent results, one of the methods is probably invalid. Remember, however, arbitrary high accuracy cannot always be attained. EDN

References

1. "Differential measurements on wideband signals," HP Application Note 1221, HP publication number 5091-3863E.
2. "Selecting oscilloscope probes for high-speed digital circuit measurements," HP product note 54720A-3, HP publication number 5091-3758E.

Author's biography



Art Porter is a product marketing engineer for Hewlett-Packard in Colorado Springs, CO. He is responsible for product and market planning as well as applications research for digital-design measurement tools. During his 30 years at HP, he has helped develop the HP180 and HP54100 series of oscilloscopes and the HP16500 series of logic analyzers.

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CIRCLE NO. 51

EDITED BY CHARLES H SMALL & ANNE WATSON SWAGER

OTAs communicate both ways

Gary Sellani, Maxim Integrated Products, Sunnyvale, CA

Wideband systems can borrow a technique from the telephone industry: use "hybrid" circuits, which halve the cost of cable by enabling transmitting and receiving over the same cable. The megahertz-bandwidth circuit in **Fig 1** uses a single 50Ω cable for bidirectional transmissions. You can easily adapt the circuit to 75Ω or other impedances.

Identical circuits, employing operational transconductance amplifiers (OTAs), terminate each end of the cable. Line-driver amplifiers IC_2 and IC_4 drive the coax, while return amplifiers IC_1 and IC_3 receive signals from the other ends. Each return amplifier also cancels any signal originating at its end of the cable. Signal IN_1, for example, drives the inverting input of IC_1 and the noninverting input of IC_2. The signal passes unchanged through IC_2 but inverts in passing through IC_1. Ideally, therefore, IN_1 gets canceled within IC_1, and IN_2 comes through the coax and appears unaffected at OUT_1. To achieve this canceling, the amplifier transconductances (g_M) must equal unity voltage gain throughout the system.

Several factors can degrade the canceling. First, phase shift in the line driver prevents the return amplifier from subtracting identical signals. Second, any transconductance mismatch in the amplifiers causes the signals to have different amplitudes, again disturbing the output null. Third, any impedance mismatch along the cable reflects signals. The nonadaptive circuits of **Fig 1** cannot distinguish between such echoes and the desired incoming signal.

Signal canceling depends on the tolerances of terminating resistors R_1, R_5, R_6, R_{10}, and their degree of mismatch with the cable's impedance. Similarly, the g_M-setting resistors, R_2, R_3, R_8, and R_9, affect the g_M for each amplifier ($g_M = 8/R$, where the 8 is an inherent property of the ICs shown and has a ±2.5% tolerance).

EDN BBS /DI_SIG #1250

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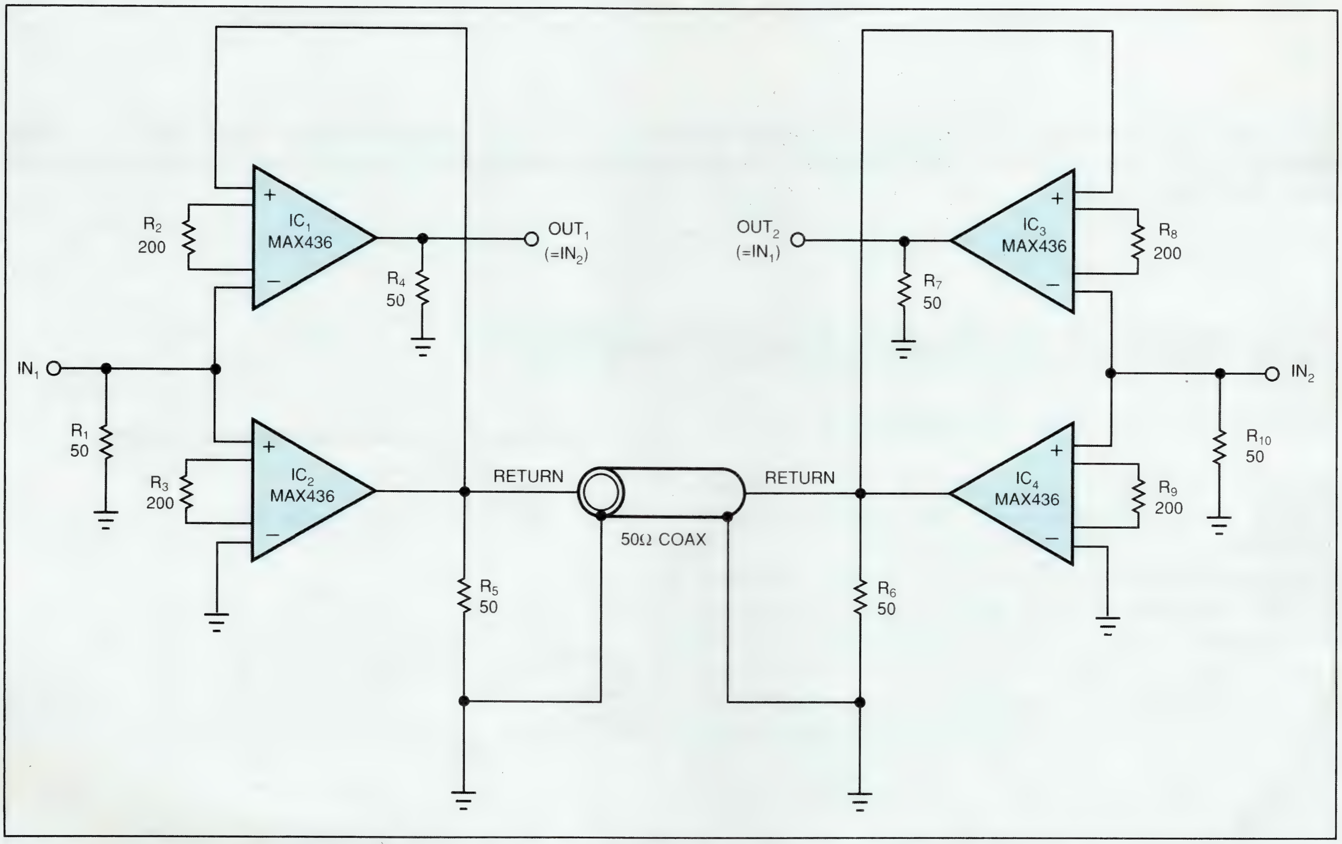

Fig 1—A pair of properly configured OTAs at each end of a coaxial cable enable bidirectional transmissions.

Scope's output nullifies current-probe delays

Stan Sasaki, Tektronix, Beaverton, OR

Calculating an instantaneous-power waveform *should* be as simple as multiplying voltage and current waveforms using your digital scope's math function. Alas, unequal path delays between voltage probes and active dc-current probes cause erroneous results. For example, an AM 503S current probe has ~20 nsec more delay than standard passive voltage probes do. This 20-nsec skew is significant considering that common power-semiconductor devices have transition times <100 nsec.

The simplest solution takes advantage of oscilloscopes' frequently overlooked signal-output spigot (usually found on the back of the instrument). First, measure the skew between your voltage and current probes, stimulating them with a fast-edged signal generator. Next, look up the input-to-output delay of the scope. Subtract the scope's delay from the total skew. Lastly, cut a length of coaxial cable, calculating its delay contribution at ~1.7 nsec/ft, which will delay the voltage signal enough to bring it in line with the current signal (**Fig 1**). **EDN BBS /DI_SIG #1249**

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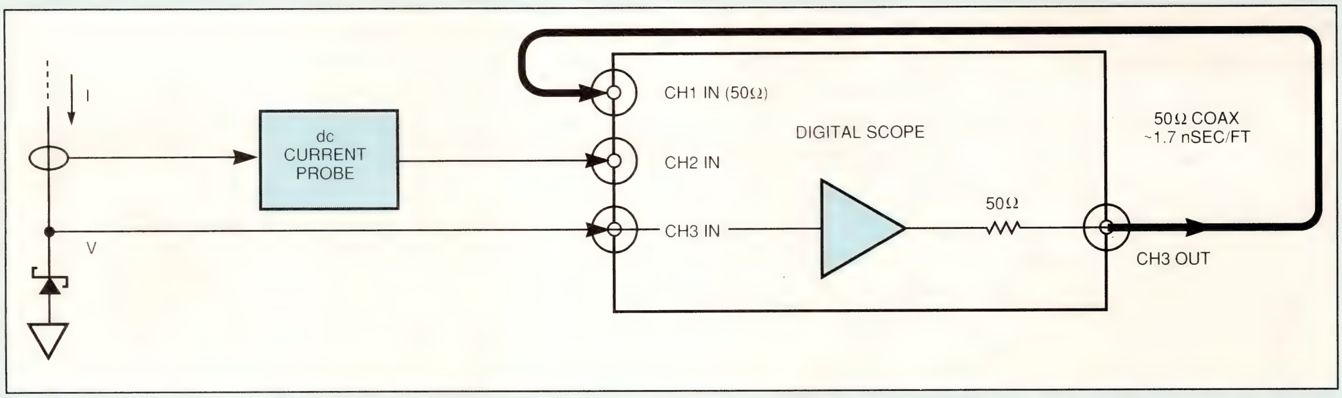


Fig 1—Using one channel of your digital scope as a buffer amplifier, you can add a calculated length of coaxial cable to a voltage signal's path. The cable's and scope's delays will nullify the often-significant skew between the responses of a passive voltage probe and an active current probe.

Trig function animates Spice comparator

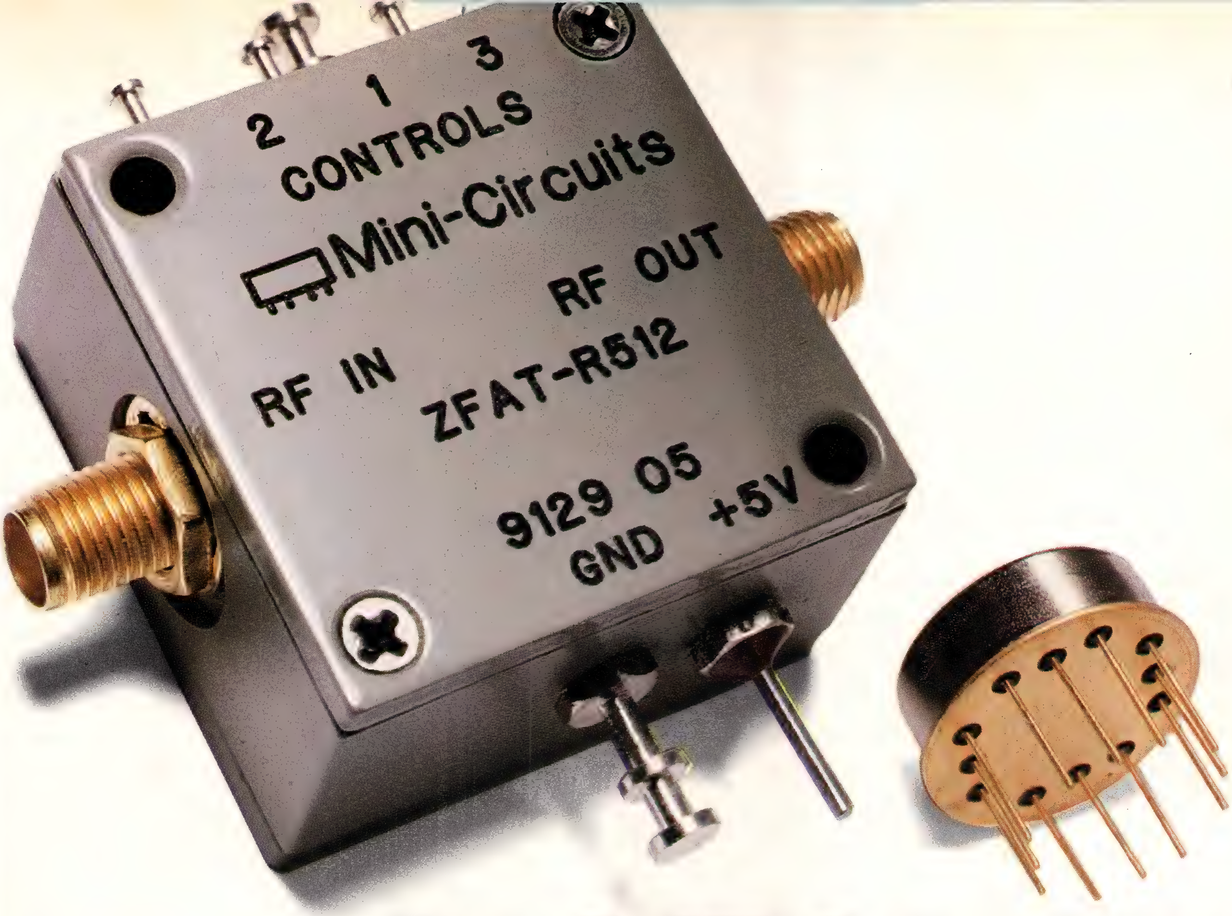
Jeff Gustus, Allied Signal Aerospace Co, South Bend, IN

Simple analog-comparator models implemented using look-up tables commonly cause convergence problems under Spice. The arctangent function provides the basis for a more well-behaved comparator model. Similar to a real comparator, the arctangent function saturates (at $\pm\pi/2$) for large positive and negative input values. With properly selected gain and offset values, a numeric function using the arctangent can generate the required output levels to model various comparators. You can also add an npn transistor as an output stage to model comparators with open-collector outputs.

Here's an example of how to calculate the parame-

Listing 1—Spice comparator model

```
.options NODE itl5=0
.temp 25
.probe
.dc lin VD      -0.0005 0.0005 1e-6


VD      10      0      DC 1

X1      10      0   30   COMPTR
RLOAD   30      0        1K


*******************************************
**           Comparator Model            **
*******************************************

.SUBCKT COMPTR   1      2      3
+       PARAMS:K1=62.831E3, K2=1.5915, VOFF=2.5

        RDI     1      2      1E6
        E1      3      0      value = ((K2*atan(K1*v(1,2)))+VOFF)

.ENDS

.end
```



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1.5	0.32	3.0	0.4	9.0	0.6	12.0	0.6	15.0	0.6
2.0	**0.2**	**4.0**	**0.3**	**10.0**	**0.3**	**16.0**	**0.5**	**20.0**	**0.4**
2.5	0.32	5.0	0.5	13.0	0.6	20.0	0.8	25.0	0.7
3.0	0.4	6.0	0.5	16.0	0.6	24.0	0.8	30.0	0.7
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CIRCLE NO. 64

F 140 REV. B

ters for the arctangent expression, where VD is the differential input to the comparator (also follow along with **Listing 1**). First define a Spice voltage-controlled voltage-source element, E:

$$E = K2 \times \mathrm{atan}(K1 \times VD) + VOFF.$$

To design a 0 to 5V comparator having a gain of 100,000, let

$$E = +5V \text{ for } VD \gg 0$$
$$E = 0V \text{ for } VD \ll 0$$
$$GAIN = 100{,}000 \text{ (from data sheet).}$$

Solve for K2 and VOFF by setting the arctangent's input arguments to large positive and negative values:

$$5 = K2 \times (+\pi/2) + VOFF$$
$$0 = K2 \times (-\pi/2) + VOFF$$
$$K2 = 5/\pi,\ VOFF = 2.5.$$

Lastly, you can approximate the linear gain, K1, of the comparator for differential input values near zero by differentiating the control function with respect to VD and solving for VD = 0:

$$\frac{d}{dVD}E = \frac{K1 \times K2}{1 + (K1 \times VD)^2}\Big|VD = 0 = K1 \times K2$$

$$K2 = 20{,}000\,\pi$$

After obtaining the three values for the particular comparator you want to simulate, simply plug them into the definition in **Listing 1. EDN BBS /DI_SIG #1251**

To Vote For This Design, Circle No. 393

Voltage sources produce FM model

Yi Young Sun, GTE Products Corp, Salem, MA

The pSpice frequency-modulator model in **Fig 1** is very useful in simulating frequency-modulation feedback circuits. The model uses voltage-controlled voltage sources to set the input-voltage range E1, generate the output frequency E2, and form the output-voltage source E3.

To use the model, first define the output voltage, EPK in Line 5 of **Listing 1**. Second, set the range of the input controlling voltage (line 7). In this case, the range is 10 to 15V. Third, line 10 defines the relationship between the input controlling voltage and the frequency. RIN defines the input impedance. **EDN BBS /DI_SIG #1252**

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Listing 1—Spice FM model

```
FREQUENCY MODULATOR
.OPT NOPAGE RELTOL=.001 NOMOD ITL5=0
VCTL CTL 0 PWL(0 10 1000U 15)
RLOAD OUT 0 10K
X1 CTL OUT 0 FREQMOD PARAMS: EPK=170           ;Line 5
.SUBCKT FREQMOD IN OUT RTN PARAMS: EPK=170
E1 1 RTN TABLE {V(IN,RTN)} = (10 10) (15 15)   ;Line 7
RIN IN RTN 10K
R1 1 RTN 1M
E2 FREQ RTN VALUE={130000-6000*V(1,RTN)}       ;Line 10
R2 FREQ RTN 1M
EOUT OUT RTN VALUE={EPK*SIN(6.28*V(FREQ,RTN)*TIME)}
.ENDS
.TRAN/OP .2U 1000U 0U .2U
.PROBE
.END
```

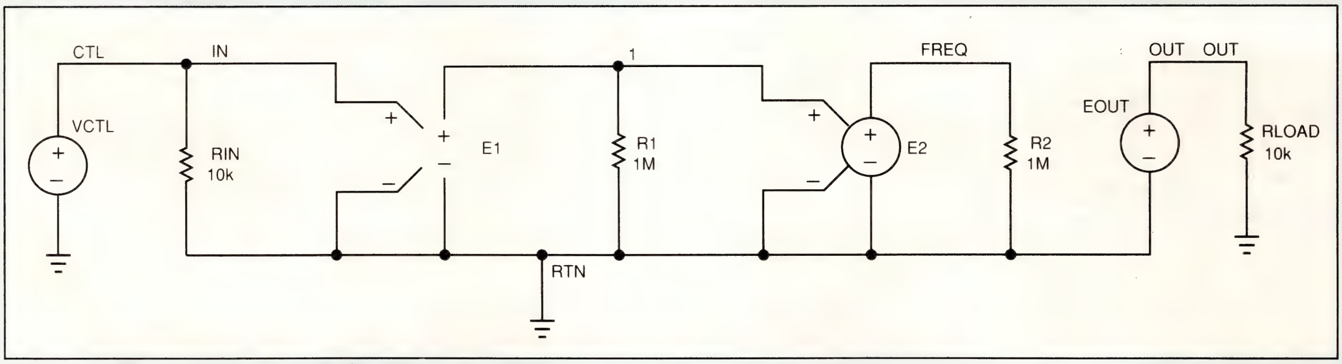
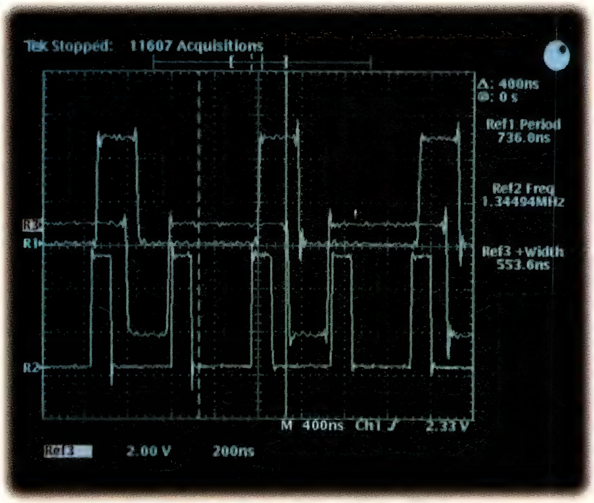


Fig 1—Three Spice voltage sources comprise a voltage-controlled FM source.



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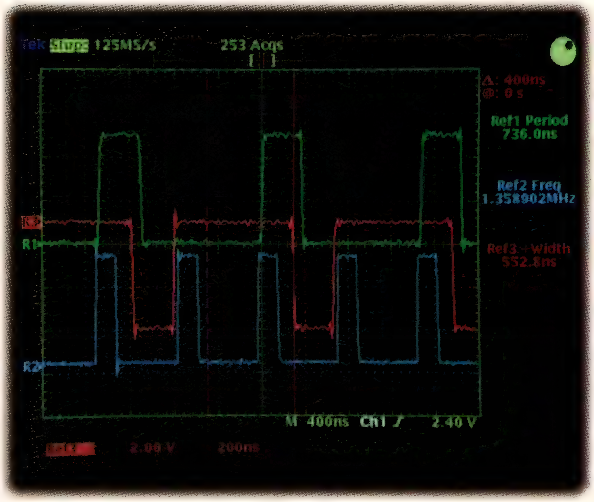

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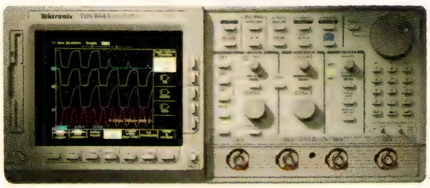

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CIRCLE NO. 65

Discharger prevents μP latchup

Derek Matsunaga, Valleylab Inc, Boulder, CO

The common resistor-capacitor μP reset circuit can cause your μP to latch up if the power cycles on and off rapidly. The discharge circuit in **Fig 1** is significantly faster than a naturally discharging resistor-capacitor combo and costs less than a dedicated watchdog-timer chip. If **Fig 1**'s 5V supply drops below the zener voltage of D_2, C_2 discharges immediately. This fast discharge ensures that the microprocessor will be reset when the 5V supply returns to its normal state, regardless the interval between power-off and -on.

IC_1 is a voltage comparator with an open-collector output, such as an LM339 or LM393. On power-up, C_2 charges to V_{CC}, and C_1 charges to the zener voltage of D_2 via R_1 and D_1. R_1 limits the current through the diodes to an acceptable level. R_2 limits current into IC_1 in the event of an internal failure. Otherwise, the noninverting input of IC_1 tracks the 5V supply.

When the power fails, the 5 and 12V supplies begin to decay. As the 12V supply decays, D_1 prevents the supply from discharging C_1. Thus C_1 maintains the zener voltage of D_2 at the inverting input of IC_1 for a relatively long time. When the noninverting input to IC_1 drops below the inverting input (plus or minus some negligible offset), the output transistor of IC_1 turns on. Thus IC_1 essentially shorts C_2 to ground through R_3. R_3 limits IC_1's collector current to about 5 mA. **EDN BBS /DI_SIG #1253**

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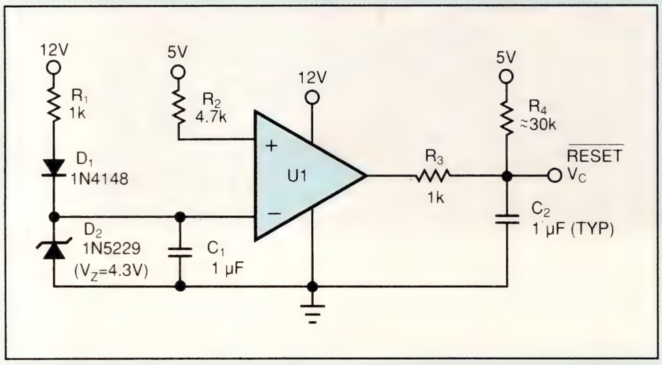

Fig 1—This quick-discharge reset circuit will not latch up a μP as a simple resistor-capacitor reset circuit can.

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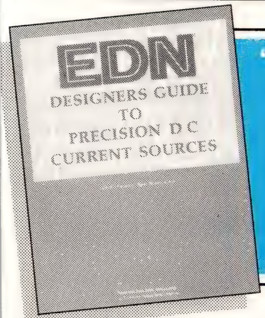

"You need only a resistor to convert a voltage to a current, but to convert accurately, the resistor voltage must ignore the load voltage."

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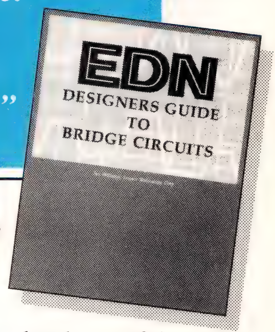

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BY JERALD GRAEME

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Jerry Graeme discusses and analyzes several circuits that use pairs of op amps. One of these circuits produces positive and negative current, which you can adjust through zero current. The Designer's Guide also shows you how to control current sources digitally. You'll find out that a current-output digital-to-analog converter may not be the best choice for a current source.

A Designer's Guide to Bridge Circuits

BY JIM WILLIAMS

Bridge circuits are among the most elemental and powerful tools a designer has. They are used in measurement, switching, oscillator, and transducer applications. If you're interested in learning about bridge circuits from Jim Williams—a specialist in analog-circuit and instrumentation design—now's your chance. Order you own copy of EDN's Designer's Guide to Bridge Circuits. This guide will help you choose and design the circuit that's most appropriate for your application. In the first part of this guide, you'll learn about dc and pulsed methods for bridge-circuit signal conditioning. In the second part, Jim describes ac-driven bridges, which you'll find in specialized applications. Also included in this section are guides to distortion measurements and bridge interfaces.

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Software Shorts

Utility converts OrCAD output

Vincenzo Carlotti, Roland Europe SpA
Acquaviva Picena, Italy

The Turbo C program in **EDN BBS /DI_SIG #1246** will put an OrCAD schematic file into the correct form for ingestion by the CBDS pc-board designer.

To Vote For This Design, Circle No. 399

Hartley transform revs DSP 96002

Pascal Staiquly, Patrice Nus, Marc Tomczack, Claude Vomscheidt
Universite de Nancy, Vandoeuvre, France.

EDN BBS /DI_SIG #1247 contains an implementation of Oscar Buneman's fast Hartley algorithm on the Motorola DSP 96002 digital signal processor.

To Vote For This Design, Circle No. 400

Monitor honchos 8051

Clive Bolton, Bolton Engineering Inc
Melrose, MA

MON51.ASM, in **EDN BBS /DI_SIG #1248**, is a simple but versatile monitor for the 8051 family. Written in 8051 assembly code, the monitor uses the 8051's internal serial port.

To Vote For This Design, Circle No. 401

Routine adds mouse to programs

Jerzy R Chrząszcz, Warsaw University of Technology
Warsaw, Poland

The C program in **EDN BBS /DI_SIG #1233** will add mouse control to existing, keyboard-driven programs.

To Vote For This Design, Circle No. 402

Design Entry Blank

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ISSUE WINNER

The winning Design Idea for the November 26, 1992, issue is entitled "LED signals lamp failure," submitted by Chester Sampson of National Semiconductor (Santa Clara, CA).

ISSUE WINNER

The winning Design Idea for the December 10, 1992, issue is entitled "Circuit extends 8052 Basic's reach," submitted by Baskaran Kasimani of Brakes India Ltd (Madras, India).

Software Shorts

Program generates noise sources

Steve Hageman, Calex Mfg Co Inc
Concord, CA

The outstanding Visual Basic program in **EDN BBS /DI_SIG #1254**, entitled PWLNOISE, produces PWL (Spice's piece-wise-linear construct) random-noise sources for Spice programs in minutes using your parameters. It also calculates the resultant noise's bandwidth and maximum slew rate.

To Vote For This Design, Circle No. 403

PLD forms adjustable pulse-width generator

Aubrey Kagan, Weidmuller Canada Ltd,
Markham, ON, Canada

The PLD file in **EDN BBS /DI_SIG #1255** programs an EP630 EPLD as an digitally controlled, adjustable pulse-width generator.

To Vote For This Design, Circle No. 404

PC printer port reads 16 inputs

Michael R Crawford
Mid-West Automation Systems, Buffalo Grove, IL

Using the simple circuit and program in **EDN BBS /DI_SIG #1256**, your PC can read 16 digital inputs through its printer port.

To Vote For This Design, Circle No. 405

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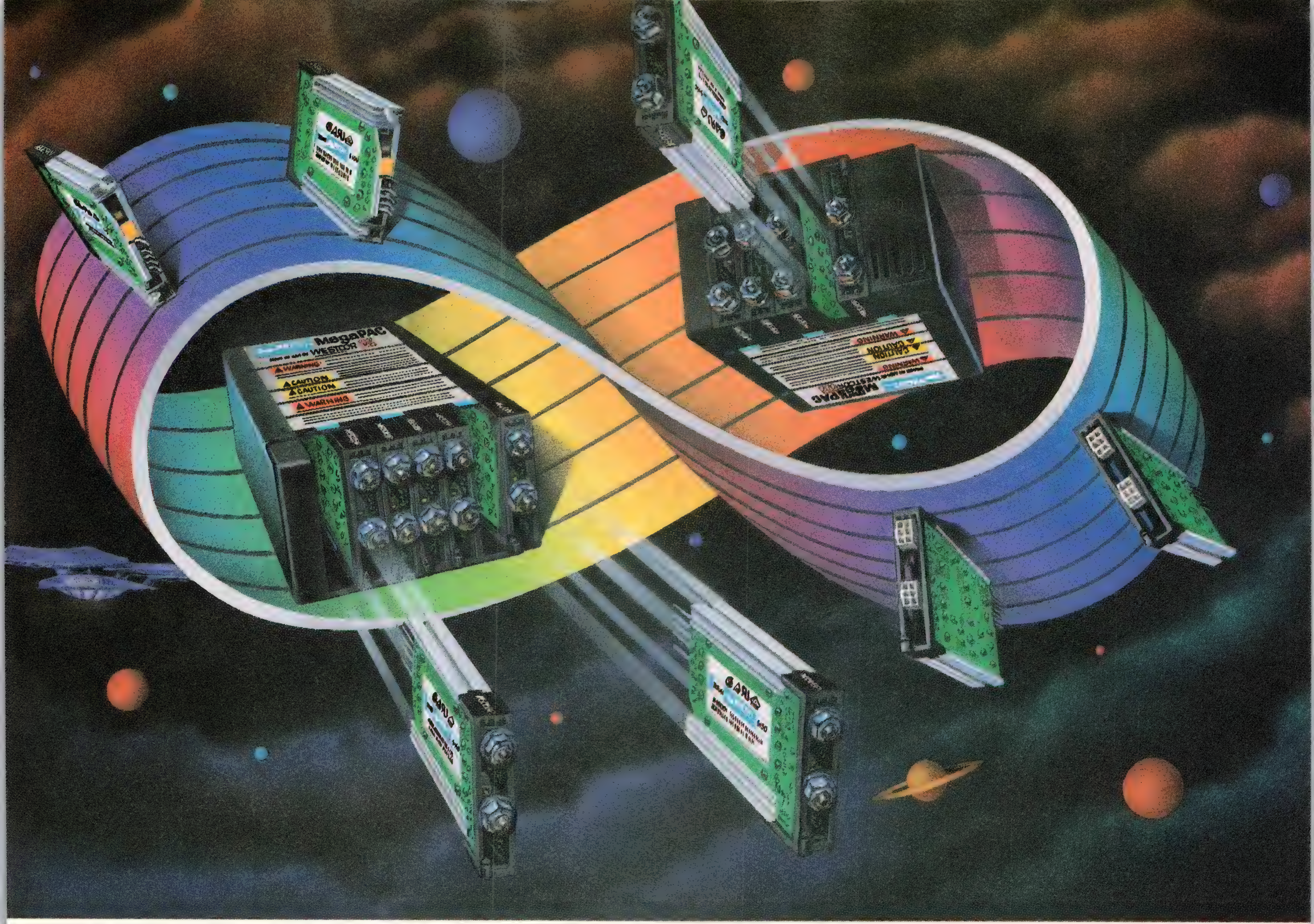
MegaPAC

Our new high-speed ADCs lower the line on power

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12-bit
2 MHz
*225 mW

Part No.	Resolution	Tested Frequency	Maximum Power	Channel Count	Supply Voltage	1000-Piece Price ($)
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MP8784	10 bit	5 MHz	225 mW	1	5 V	12.96
MP8795	10 bit	1 MHz	50 mW	1	5 V	10.40
MP8798	10 bit	1 MHz	50 mW	4	5 V	13.83
MP8799	10 bit	1 MHz	50 mW	8	5 V	15.44
MP8775	8 bit	20 MHz	125 mW	1	5 V	6.44
MP87L91	12 bit	1 MHz	50 mW	1	3.3 V	31.92
MP87L84	10 bit	2 MHz	50 mW	1	3.3 V	13.60
MP87L95	10 bit	0.25 MHz	10 mW	1	3.3 V	10.92
MP87L75	8 bit	10 MHz	35 mW	1	3.3 V	7.08

The devices described in the chart represent major product groups. Prices shown are for PDIP. Other package options are available.

We give you the competitive edge for power-critical applications. Whether you are building a high-resolution imaging system or a fax machine, a color copier or a digital cellular telephone, you get a greater degree of design freedom. Low-power converters add far less heat and noise to your system. That means no heat sinks, better system-level signal-to-noise, and a straightforward design-in.

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5 MHz
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**All power ratings shown are guaranteed maximums.*

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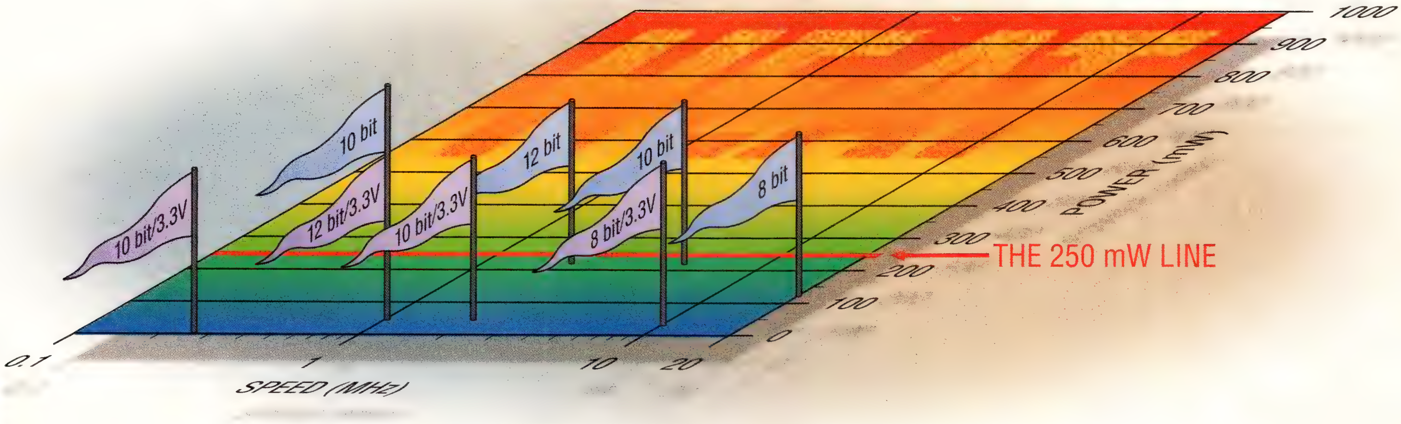

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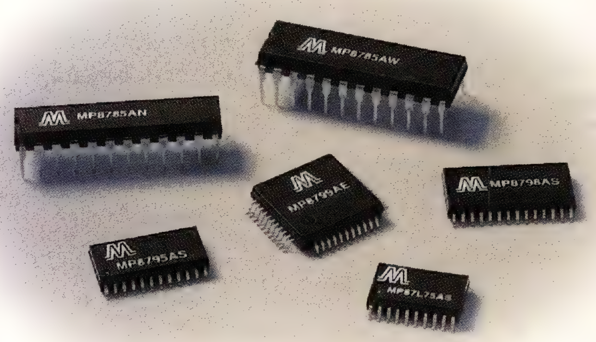

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**125 mW*

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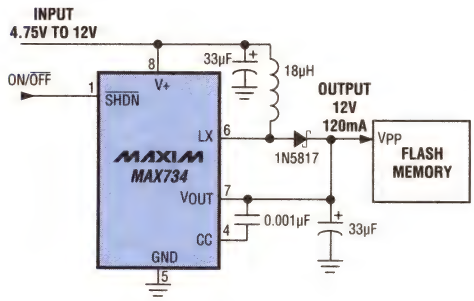
MAXIM DESIGN NEWS
Analog Design Insights from Maxim Integrated Products No. 26

Flash Memory & PCMCIA Power Supplies for 3V & 5V Systems

12V, 120mA 8-Pin SO Flash Programmer Fits into < 0.3in²

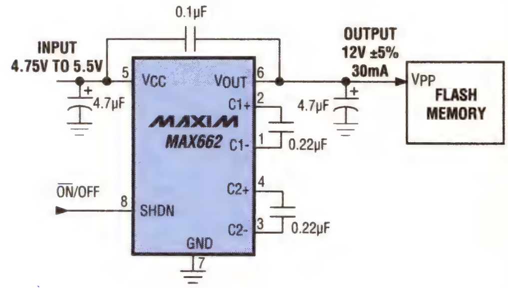


The **MAX734** comes in an 8-pin SO package and delivers 120mA at 12V (+5%, -3%), guaranteed over temperature, from 4.75V to 12V inputs. The complete circuit fits into 0.3in^2. 83% efficiency at full-load and 70µA supply current in shutdown save battery life. PWM control assures fixed-frequency output ripple for noise-sensitive and communications applications. Priced at $2.00 (10,000 pcs*). Evaluation kit available (MAX734EVKIT-SO).

* FOB, USA.

(Circle 1)

World's Lowest-Cost & Smallest Flash Programming Supply Needs No Inductors

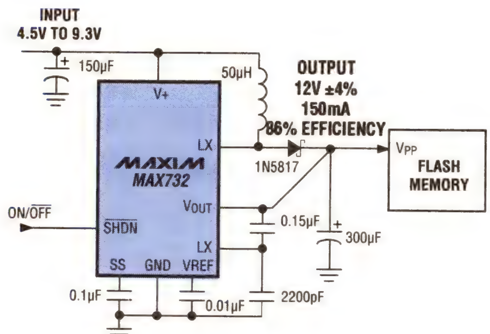


The **MAX662** charge-pump programming supply for flash memories fits in 0.2in^2 and uses only low-cost capacitors to provide a regulated 12V ±5% output. Guaranteed output current is 30mA for 4.75V to 5.5V inputs. No-load current is 320µA, which drops to 70µA in shutdown. The MAX662 comes in 8-pin DIP and SO packages and is priced at $1.85 (10,000 pcs*). Evaluation kit is available (MAX662EVKIT-SO).

* FOB, USA.

(Circle 2)

12V, 150mA Flash Programmer Fits into < 0.5in²

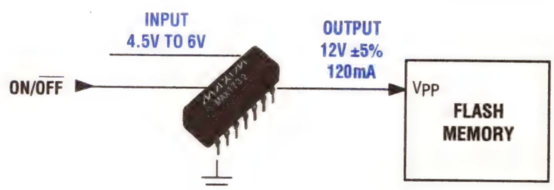


The **MAX732** comes in a 16-pin SOIC package and delivers 150mA at 12V ±4%, guaranteed over temperature, from 4.5V to 9.3V inputs. The complete circuit fits into < 0.5in^2. Battery-saving features include 86% efficiency and 55µA quiescent current in shutdown mode. PWM control and 170kHz fixed-frequency switching allow easy filtering of output ripple. Priced at $2.50 (10,000 pcs*). Evaluation kit available (MAX732EVKIT-SO).

* FOB, USA.

(Circle 3)

Complete Flash Memory Programmer Fits in 14-Pin DIP (0.25in²) 12V at 120mA – No External Components



The **MAX1732** is a complete 12V, 120mA flash memory programming supply in a single 14-pin DIP. It requires no external components and occupies only 0.25in^2 of board space. It is 0.3in high. Full-load efficiency is 85% and supply current is 70µA in shutdown mode. Output regulation is ±4% guaranteed over all line, load, and temperature conditions. PWM control allows easy filtering of output ripple in noise-sensitive applications. The MAX1732 is available in the commercial temperature range (0°C to +70°C).

(Circle 4)

Xicor®

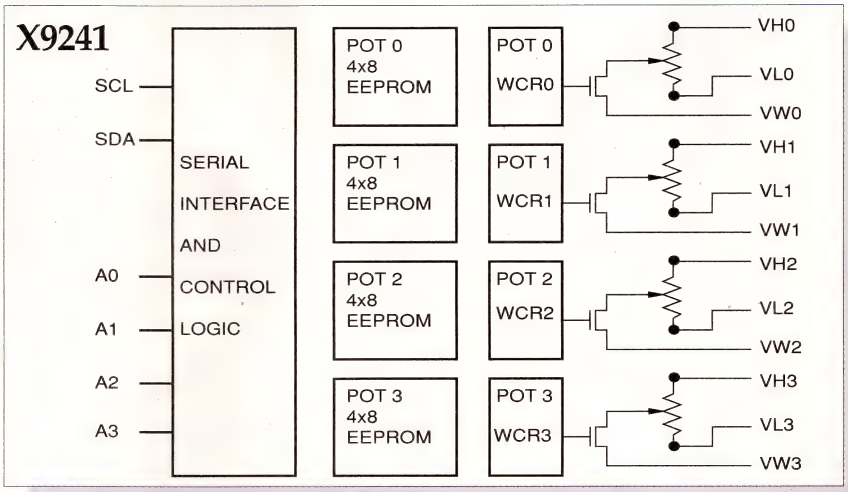
#2
Q1/93

Design Engineers Bulletin

New Product and Applications Information for Design Engineers

Xicor's New X9241 Quad Potentiometer Allows Factory Automation of 64 Potentiometer Adjustments via a Digital Two Wire Serial Bus

For complex systems requiring multiple adjustment capability, Xicor offers the new X9241, Quad E²POT. In addition to retaining wiper positions without power, the X9241 offers a two-wire serial interface for controlling the potentiometers independently or simultaneously using microprocessor control commands. A user programmable address allows up to 16 devices to be software controlled via the common two wire serial bus.



QUAD E²POT Development System

PC based system automates production adjustments of system potentiometers

The XK9241 can be used in a production environment to optimize the settings of the E²POT.

Faster analog circuit checkout and calibration is made possible by Xicor's new XK9241W Quad E²POT Development System. This system consists of an X9241 evaluation board, interface cables and software which allows a design engineer to control all functions of the Xicor X9241 Quad E²POT from a menu driven system on a IBM PC Compatible computer. The XK9241W Development System allows the design engineer to place the X9241 in a target analog system and perform all adjustments and configuration needed to recognize the features and benefits of the Quad E²POT. The XK9241 PC based development system can also be used in production environments to automate potentiometer adjustments for initial system calibration.

The XK9241 supports all versions of the X9241 family. It can simultaneously control up to 16 different Quad E²POTs on the same two-wire bus to effectively allow adjustment of 64 individual E²POTs. Orders for the XK9241W can be placed with any authorized Xicor distributor. Suggested resale price is $299.00.

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0.6-micron rule for workstations and other high-end 5V systems.

Our CMOS-8 gate arrays feature a 0.6-micron rule and a loaded speed* of 180 picoseconds. The family includes 11 masters with 5-to-163K usable gates, and 156 to 660 I/O pads. Supply voltages cover the range from 2.7V to 5.5V.

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*F/O = 2, l = 0.5 mm   CrossCheck: registered trademark of CrossCheck Technology Inc.

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CIRCLE NO. 131

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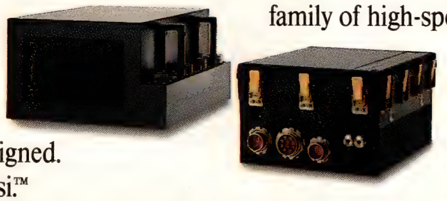

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CIRCLE NO. 118

My job, your job

Your job is to make things work. You place a µP or µC of some sort into a product and then create code that performs a wild and wonderful function. To get your job done, you use a variety of embedded-systems development tools. My job is to fill this new section in EDN with information about the tools that will make your life easier.

There are many changes on the way. Everyone is aware that the percentage of development costs devoted to software is increasing. Time-to-market is shrinking, and the short time it now takes to create working code is having a great effect on the system design. It's not hard to extrapolate that in the future the tool set will be **the** deciding factor in embedded-systems hardware design.

Tools and techniques have come a long way. In the mid-seventies, I was using Prolog coding sheets to hand-assemble code for the Intel 4004. After converting the machine language into hex, I would then burn an EPROM (1702), plug it into the target system, watch what happened, and then fall into a "repeat until working" loop.

Since then, I have used many different processors and DSP chips as well as a variety of development tools. Each of these new products allowed some increase in productivity. But we still design the software, write the code, let it run, and then scratch our heads to figure out what went wrong.

I recently replaced the 4004-based instrument, which has been operating all these years on a research submarine, with a Z180 version that was written entirely in C. A monitor program on the target system allowed me to use a source-level debugger to speed the development along. Instead of staring at the assembly listing, I spent my time staring at the source code on the debugger...and scratching my head.

We have a long way to go before we can quickly generate error-free code for even simple embedded applications, let alone complex ones. But you have a job to do now. You have to get the project in front of you out the door. To do your job, you need to know what tools are here today and what tools are on the way. It's my job to keep you informed.

—David Shear

Neural network and fuzzy logic combine to create COP8 code

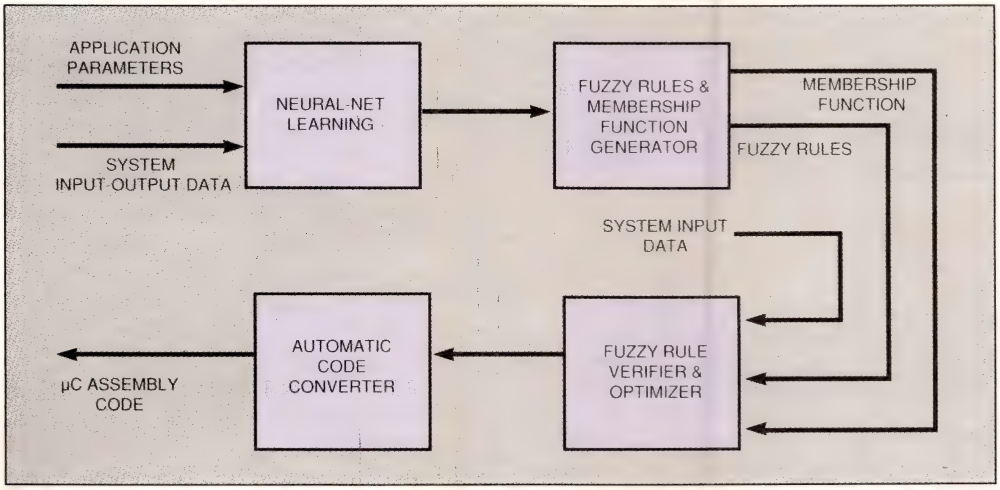
In an attempt to combine the best of fuzzy logic and neural networks, National Semiconductor has created NeuFuz4. This development package uses a neural network to build expertise into systems and assist you in creating systems based on fuzzy logic.

Fuzzy-logic proponents claim that fuzzy makes it easier to use in some applications than using conventional programming methods. But generating fuzzy rules and membership functions can be very difficult. These can be a long and tedious processes, and you have to tune the membership functions and rules until you can meet the needs of your system.

NewFuz4 uses neural networks to take the application parameters and system input/output data and create the fuzzy-logic rules and membership sets. The resulting rules and membership functions are then given to a fuzzy rule verifier and optimizer, which simulate the operation of the system. The optimizer will also guide you on rules that can be removed.

If you are not pleased with the results, the neural-net learning function can tune the rules and membership functions. When you approve the simulation, the package can automatically create assembly-language code for the COP8 µC. (Later this year, the package will create C code for use on any µC with a C compiler).

Three versions are available. The Learning Kit (NF2-C8A-KIT) costs $199 and allows you to play with



The neural-network front end accepts a description of your application parameters and creates fuzzy rules and membership functions. Once the resulting design can be verified, the code for the COP8 can be generated.

a limited version of the complete package. The Development Kit (NF4-C8A) costs $3975 and includes the standard package and one year of support. The Development System (NF4-C8A-SYS) costs $10,000 and includes all of the software, a COP8 debug module, and one year of support, training, and access to an expert consultant for 16 hours.

—David Shear

National Semiconductor, Santa Clara, CA. Phone (800) 272-9959. **Circle No. 388**

Profiling tool added to Spectra

Xpert Profiler is an operating-system-independent tool that provides analysis of system performance and reliability. It is compliant with Ready Systems' Spectra, which is an open cross-development backplane.

Xpert Profiler is designed for minimal target intrusion and will reduce application distortion and allow for more accurate monitoring. The tool can help you identify execution bottlenecks and unmet deadlines. It also tracks system flow and ISR (interrupt service routine) nestings. It includes a task-switching display and operating-system overhead measurement when used with an operating system built on top of Ready Systems' Nanokernel.

It also has display and monitor programs. The display program presents graphical data in two ways: in a timeline and in a statistics table. The timeline graphically represents execution threads with optional display of user-defined probes, stimulus response, and critical deadlines. The statistics-table display provides statistical analysis, such as maximum-, minimum-, and average-task-execution time, and deadline information.

The monitor program executes on the host and uses Spectra's ToolBuilder Interface to supervise the event-monitoring process. Events are collected by the target and then sent to the host. The monitor program configures the operation of Xpert Profiler and lets you define the buffer size, sampling period, timing resolution, ISR monitoring, and sampled data.

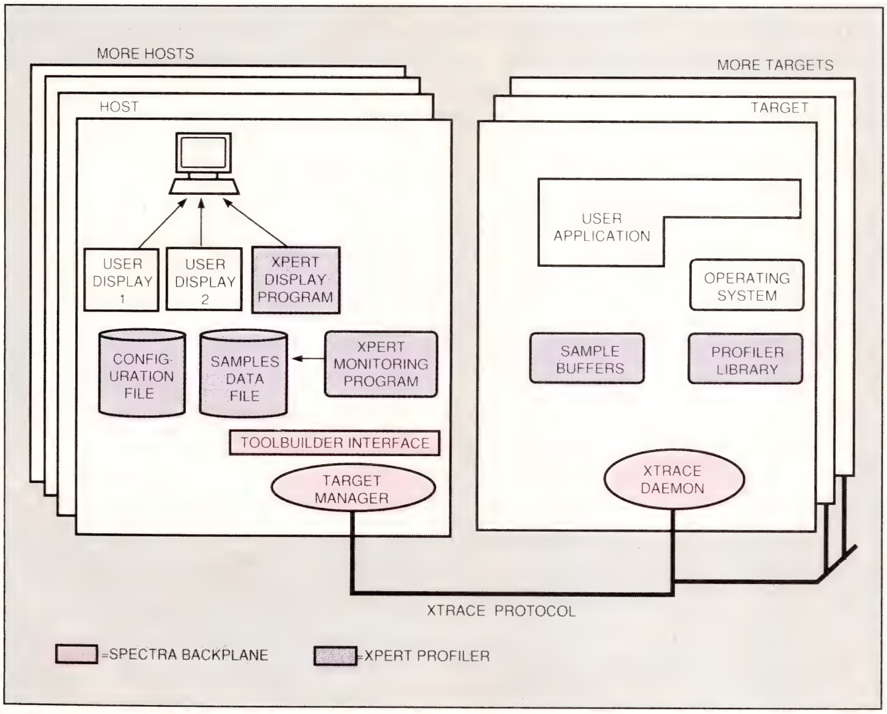
Xpert Profiler uses Xtrace Daemon to communicate between the target and the host, eliminating the need for a special monitoring thread in the target.

User-defined measurement parameters determine what data the target collects and how often. You can choose the timer granularity in units of clock ticks, microseconds, or milliseconds. You can acquire the execution time of specific instrumented blocks of code, flag specific points in the program, and obtain timing data about ISRs. The target collects the data by instrumenting code segments of interest.

Xpert Profiler ($3000) can also be used without target hardware by using Spectra's Virtual Target.**—David Shear**

Ready Systems, Sunnyvale, CA. Phone (408) 736-2600. Fax (408) 522-7102.

Circle No. 390



The Xpert monitoring program controls the performance data acquired by the target. When the sample buffers in the target are full, the data is sent to the host where it is presented by the Xpert display program.

Tool set for 68HC08

This integrated set of tools for Motorola's new 68HC08 μC includes the Micro-C C compiler from Dunfield Development Systems, the MCX-08 real-time operating system (RTOS) from AT Barrett and Associates, the SIM08 simulator, RCASM08 relocatable assembler, and the environment from P&E Microcomputer Systems.

This is not a package where three vendors just stuck their products in the same box and called them integrated. The companies have worked together, and the environment from P&E Microcomputer Systems provides a consistent look and feel for the tools. It includes an editor with help files for the compiler, RTOS, simulator, and assembler.

The compiler and assembler generate debug maps for use with the simulator. The simulator supports symbolic source-level debugging and has a multiple window screen that lets you view a variety of data. Besides the internal registers and port values, you can view memory (including XX for uninitialized and UU for unimplemented memory), source code, and commands.

The RTOS has 32 services, which include task management, semaphores, messages, queues, timer management, and interrupts. It offers preemptive, round-robin, and time-sliced scheduling. An advanced and extended version will be available this year that will add

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services at an additional cost. The simulator is not RTOS aware, but there are plans to make this feature available.

One advantage of using the simulator is that the timer is also simulated. Therefore, when you are debugging your code, the timer stops when execution stops. This lets you to also debug the timer routines, which is sometimes difficult to do because the timer keeps running on breakpoints.

The simulator also includes a cycle counter that will count the execution cycles and provide estimates on execution time. You can also pull up a screen that will compare the execution time of the 68HC08 to the 68HC05 running the same code. If you are considering upgrading to the 08 from the 05, you can run your 05 code directly on the 08 simulator to see how much faster it will run on the new µC.

You can also get an absolute assembler and the simulator free from Motorola. P&E Microcomputer Systems created the assembler and simulator that Motorola distributed for the 68HC05 as well as the one being given away for the 68HC08.

Even though this package is intended for developing products based on the 68HC08, its $495 price will make it attractive to those who just want to learn more about using C and a real-time operating system on a µC. —**David Shear**

P&E Microcomputer Systems Inc, Woburn, MA. Phone (617) 944-7585.

Circle No. 389

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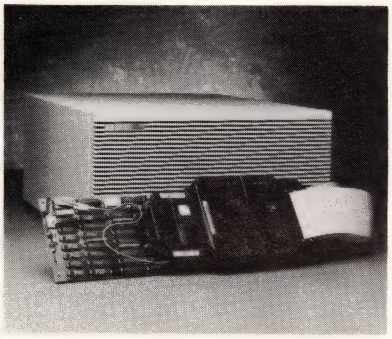
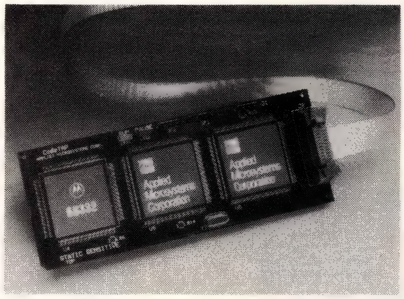
Active-probe emulator for 68040. The emulator provides zero-wait-state operation to 25 MHz and one-wait-state operation from 25 to 33 MHz for Motorola's 68040, 68EC040, and 68LC040



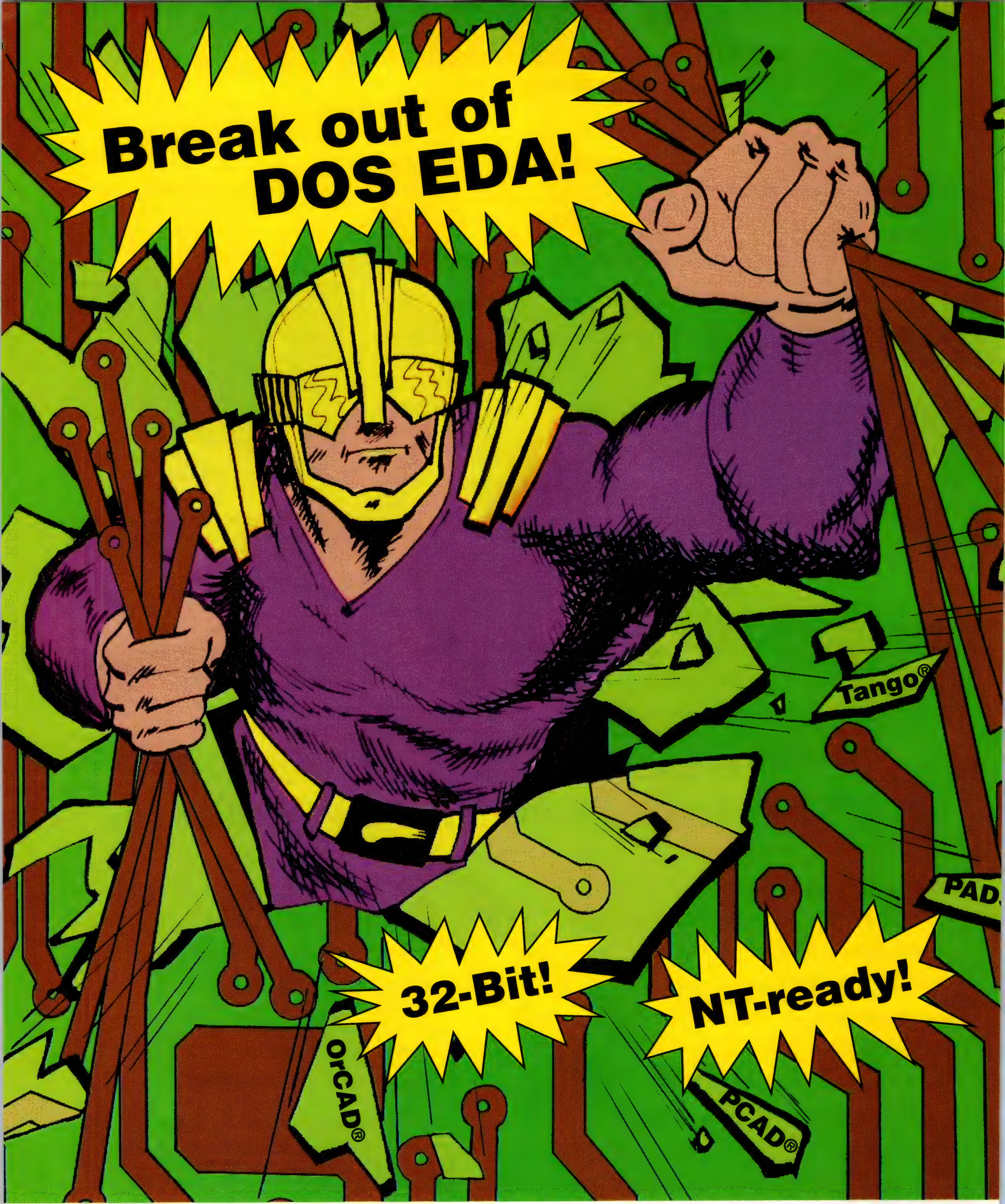
μPs. The active probe contains μP circuitry to minimize the intrusion of the emulator into the target system. A terminal-based system, which includes the active-probe with space for 2 Mbytes of memory, an HP 64700A card cage, and an 80-channel, 1k-deep emulation-bus analyzer, costs $25,150. **Hewlett-Packard Co,** Santa Clara, CA. Phone (800) 452-4844. **Circle No. 424**

3V 80186 emulator. The MICE-III and MICE-IIIS emulators now support the Intel 80L186EA 3V version of the 80C186 along with the C186 and C186XL CPUs. The emulators can run with a clock of up 20 MHz with no wait states in either the target or overlay memory. The MICE-IIIS-80C186EA has a 32-kbyte trace buffer and 1 Mbyte of zero-wait-state memory. The MICE-III starts at $10,500, and the MICE-IIIS starts at $12,500. The Hypersource source-level debugger is included. **Microtek International,** Hillsboro, OR. Phone (503) 645-7333. Fax (503) 629-8460. **Circle No. 425**

68332 in-circuit emulator. The CodeTAP-XA (extended architecture) in-circuit emulator now supports the 68332 μC at up to 16 MHz with zero wait



states. The trace dissassembler shows register contents as they change. A sequential event system allows you to chain together up to four event detectors. The CodeTAP-XA also includes statistical performance analysis, 256-kbyte to 1-Mbyte overlay memory, 4k × 144-bit trace, and a high-level language debugger. It will run on both PCs and Sun SPARCstations. $9000. **Ap-**



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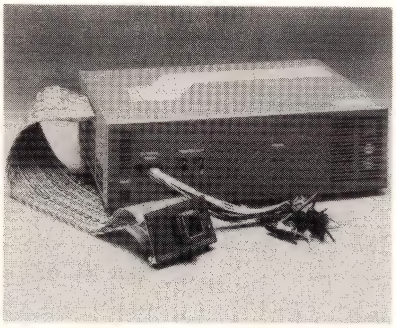
plied Microsystems, Redmond, WA. Phone (206) 882-2000. Fax (206) 883-3049. **Circle No. 426**

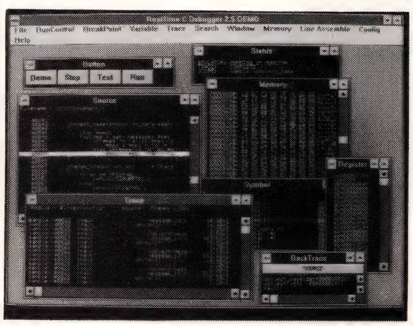
In-circuit emulator for 68333. The HMI-200 Series of in-circuit emulators has expanded to include the Motorola 68333 µP. The units offer real-time



emulation to 16 MHz, four complex break-and-trigger points, two 4k × 104-bit trace buffers, and 256 kbytes to 2 Mbytes of overlay RAM. All three of the 68333's operating modes (16-bit, 8-bit expanded, and single chip) are supported. The SourceGate control and source-level debugging software, which runs on PCs or Unix workstations, is included. $16,000. **Huntsville Microsystems Inc,** Huntsville, AL. Phone (205) 881-6005. Fax (205) 882-6701. **Circle No. 427**

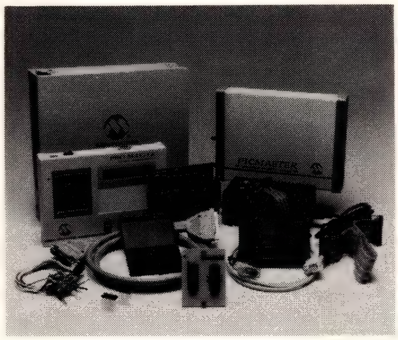
Pentium in-circuit emulator. The LA/ICE-I5 combines the ML4400 logic analyzer with additional hardware and software to provide in-circuit emulation for Intel's Pentium µP. The LA/ICE-I5 uses emulation features included on the µP to start and stop, set breakpoints, single step, and examine and change internal data. The ML4400 logic analyzer adds real-time trace, triggering, and overlay-memory functions. The SoftProbe debugger runs on a PC and provides control and display functions for the system. $32,975, fully equipped; $11,995 without the ML4400 logic analyzer. **American Arium,** Tustin, CA. Phone (714) 731-1661. Fax (714) 731-6344. **Circle No. 428**

Real-time C emulator interface for PCs. A Microsoft Windows-based interface to the HP 64700 Series emulators runs on IBM-compatible PCs and allows interaction with the emulators in C or assembly language. With this interface, which until now was only available for workstations, you can make debugger



measurements, such as monitoring C variables, without stopping the processor. $1250. **Hewlett-Packard Co,** Santa Clara, CA. Phone (800) 452-4844. **Circle No. 429**

PIC16C84 development system. The PICMaster-16C provides full-speed, real-time in-circuit emulation for Microchip's PIC16C84 μC. The system



includes a target probe, the PRO MASTER programmer, and all required software. It runs on IBM-compatible PCs under Microsoft Windows. $3450. **Microchip Technology Inc,** Chandler, AZ. Phone (602) 786-7200. Fax (602) 899-9210. **Circle No. 430**

Windows-based DSP development. The WBC25 DSP Workbench provides a Microsoft Windows 3.1 environment for DSP development. You can develop DSP code with TI's C25 C compiler/assembler and then download to the system's benchtop board for test. The Direct Access Boot Kernel runs on the board and communicates with the PC running the Windows program via the parallel port. The board includes a 50-MHz TMS320C25, 128k×16-bit zero-wait-state SRAM, 64k×16-bit EPROM, and 128k×16-bit flash memory. $695. **Micro Platforms,** Seattle, WA. Phone (206) 527-7929. Fax (206) 527-8012. **Circle No. 431**

STREAMS-based networking executive. STREAMS are used in the development of communications services by providing a standardized framework for communication drivers. SNX (STREAMS Networking Executive) and SNX+ support multiple operating systems including VRTX32 kernel, VRTXsa kernel, or any Nanokernel-based operating system. The executives have been designed specifically for real-time applications. SNX and SNX+ are based on source code from Spider Software and support a variety of networking protocols. SNX costs $5300, and SNX+ costs $6200. **Ready Systems,** Sunnyvale, CA. Phone (408) 736-2600. Fax (408) 522-7102. **Circle No. 432**

Shorts

80-channel emulation bus analyzer offers 8k to 256k deep trace buffer for HP 64700 series emulators. **Hewlett-Packard Co.** (800) 452-4844. **Circle No. 433**

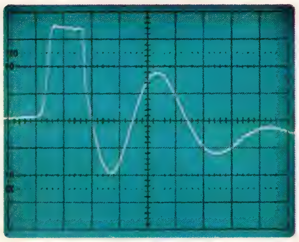
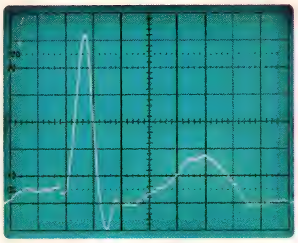
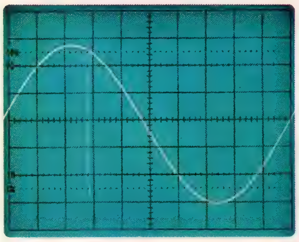
68HC000 and 68EC000 probe tips and modules are now available for the EL 1600 in-circuit emulator. **Applied Microsystems Corp.** Phone (206) 882-2000. **Circle No. 434**

CenterLine Software's ObjectCenter C++ programming environment has been integrated with VxWorks and Microworks real-time embedded development environments. **Wind River Systems.** Phone (510) 748-4100. **Circle No. 435**

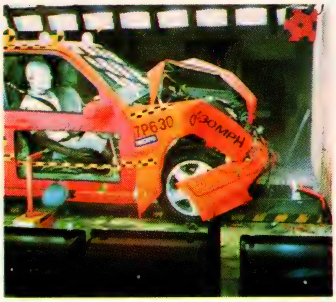
Revisions

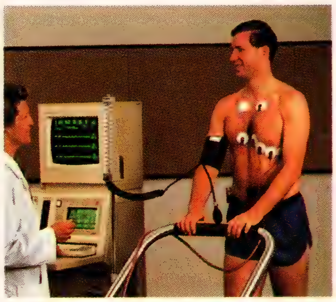
The HP graphical-debug environment, release 1.1, adds support for HP's SoftBench software-development framework. **Hewlett-Packard Co.** **Circle No. 436**

Real life simulation.

Without doing this.



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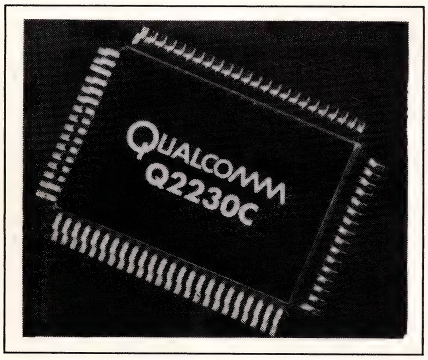
CIRCLE NO. 126

Integrated Circuits



Direct digital synthesizer (DDS). The single-chip Q2230 DDS has a maximum clock rate of 85 MHz, which lets it synthesize sine waves from 0 to 42 MHz. The chip has a frequency control interface, a 32-bit accumulator, a 15-bit sinewave lookup table, and an output from a 12-bit DAC. You can program the frequency control interface to frequency hop with an output latency of 14 system clocks. $28.50 (1000). **Qualcomm Inc,** San Diego, CA. Phone (619) 587-1121. Fax (619) 452-9096. **Circle No. 401**

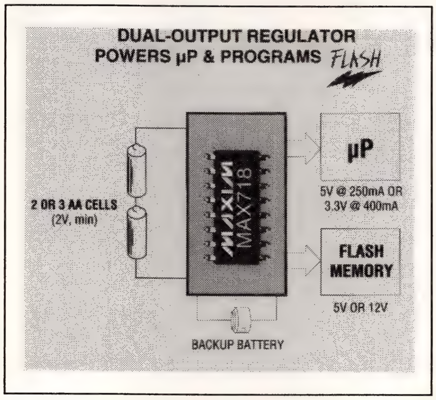
2-Mbit VRAM. The KM428C256 2-Mbit video RAM (VRAM) has an access time as low as 60 nsec. The 0.6-µm chip has a 256k×8-bit organization and uses both a conventional dynamic RAM and a serial access memory (SAM). Dual ports can asynchronously access both memory types. The SAM port has an 18-nsec cycle time. $19 (1000). **Samsung Semiconductor Inc,** San Jose, CA. Phone (800) 446-2760; (408) 954-7000. **Circle No. 402**

GaAs ASICs. This GaAs gate-array family has ECL, TTL, and GaAs-compatible I/O ports that operate as fast as 1 GHz. The arrays have from 10,000 to 100,000 gates and feature gate delays of 50 psec. Power dissipation is 0.35 mW at 1 GHz. You can implement a D flip-flop having a toggle rate of 1.8 GHz. NRE, $75,000 to $150,000. **Rockwell International Corp,** Newport Beach, CA. Phone (714) 833-6849. **Circle No. 403**

Fuzzy coprocessor. The SAE 81C99 has an 8-bit interface to either a µC or µP. The fuzzy coprocessor offloads calculations from the host and reaches a peak performance of 7.9 million rules/sec at 20 MHz. A MIN-MAX or MIN-BSUM algorithm calculates the weights. The chip handles 256 inputs, 64 outputs, and 16,384 rules. $32. **Siemens Corp,** Santa Clara, CA. Phone (408) 980-4518. **Circle No. 404**

Instrumentation amplifiers. The PGA204 and PGA205 are programmable instrumentation amplifiers. The PGA204 provides decade gain steps of 1, 10, 100, and 1000 V/V. The PGA205 has binary steps of 1, 2, 4, and 8 V/V. The amplifiers have a maximum offset voltage of 50 µV and a maximum drift of 0.25 µV/°C. The gain error is 0.024%, and the nonlinearity is 0.002%. $6.50 (1000). **Burr-Brown Corp,** Tucson, AZ. Phone (602) 746-1111. Fax (602) 889-1510. TWX 910-952-1111. **Circle No. 405**

Multiplying DAC. The MAX543 12-bit multiplying DAC comes in an 8-pin small-outline package. A serial input to an on-chip 12-bit register minimizes board space. Separate CLK and LOAD control pins let you load and update the converter in separate operations. Other features include 1-µsec settling time, 20-nV/sec glitch energy, and 1-mV_{p-p} feedthrough for a 10 kHz, ±10V input signal. $4.25 (1000). **Maxim Integrated Products,** Sunnyvale, CA. Phone (408) 737-7600, ext 6087. **Circle No. 406**



Dual-output switching regulators. The MAX717 and MAX721 operate from input voltages as low as 1.8V and provide a main output voltage of 3.3 or 5V and an auxiliary output of 5 or 12V. You can use a MOSFET on the auxiliary output to supply more than 120 mA for programing flash memories. Efficiency ranges from 80 to 87%, and the switching frequency can be as fast as 500 kHz. From $5.95 (1000). **Maxim Integrated Products,** Sunnyvale, CA. Phone (408) 737-7600. **Circle No. 407**

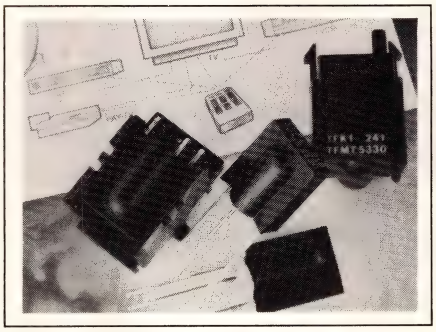
Linear active filters. The D68 series consists of lowpass or highpass active filters in a 0.3-in.-high package. Model types include 8-pole Butterworth, 8-pole 6-zero elliptic, 8-pole Bessel, and 8-pole 6-zero constant delay responses. User-specified corner frequencies range from 10 Hz to 100 kHz. The units have typical ±1° unit-to-unit phase matching. $115 (1000). **Frequency Devices Inc,** Haverhill, MA. Phone (508) 374-0761. Fax (508) 521-1839. **Circle No. 408**

LCD controller. The SED1560TOB is a single-chip LCD controller and driver for handheld applications. In active mode, the chip draws 350 µA from a 3V supply and 0.05 µA in a deep sleep mode. The chip drives displays as small as 17×150 pixels and as large as 65×102 pixels. You can configure several devices together to drive larger displays. $8.25 (1000) in a TAB package only. **S-MOS Systems,** San Jose, CA. Phone (408) 954-0120. Fax (408) 922-0578. **Circle No. 409**

SCSI-2 to ISA bus adapter. The 53C400A single-chip SCSI controller has logic to interface with an ISA bus. The chip has 256 bytes of on-chip RAM to use as a scratch pad by the BIOS. In addition, the chip features the company's TolerAnt Active Negation Technology, which improves data integrity. TolerAnt drivers actively control the maximum voltage and current to the SCSI cable. $9 (1000). **NCR Corp,** Dayton, OH. Phone (800) 334-5454; (303) 226-9550. **Circle No. 410**

Integrated Circuits

Wide-word static RAM. The LH-521028 64k×18-bit SRAM suppresses ground bounce associated with fast wide-word memory parts by using six ground pins and six power pins. The chip also includes transparent address latches. A flexible bus architecture can be 8, 9, 16, or 18 bits wide. Access times are 20 nsec, $70; 25 nsec, $65; and 35 nsec, $60. **Sharp Electronics Corp,** Camas, WA. Phone (800) 642-0261; (206) 834-2500. **Circle No. 411**



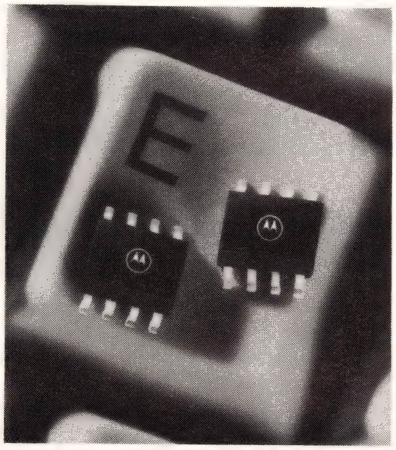
Infrared receivers. The TFMS 5xxx and TFMT 5xxx combine a photoelectric PIN diode, an AGC amplifier, a bandpass filter, and a demodulator on a single chip. The chip suits infrared remote-control systems. Manufactured to ISO 9000 standards, the device doesn't require external components. $2.11 (1000). **Temic,** Santa Clara, CA. Phone (800) 554-5565, ext 83; (408) 988-8000. Fax (408) 970-3950. **Circle No. 414**

8-bit microcontroller. The DS80C320 μC is a drop-in replacement for the 8051 μC and is 2 to 3× faster. The chip operates at clock speeds from 0 to 25 MHz and delivers 6 MIPS at 25 MHz. Besides enhanced 8052 features such as three 16-bit timers, an on-chip UART, 256-byte RAM, and four 8-bit I/O ports, the chip adds dual data pointers, two UARTs, power monitor, watchdog timer, and additional interrupts. $6.50 (10,000). **Dallas Semiconductor,** Dallas, TX. Phone (214) 450-0448. Fax (214) 450-0470. **Circle No. 415**

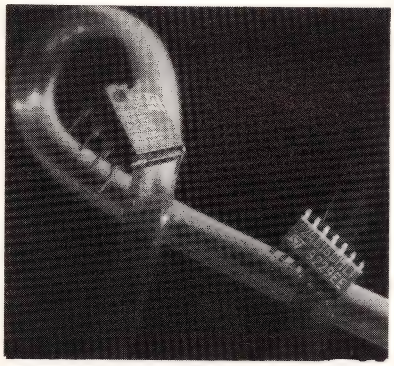
4-bit microcontroller. The MN155202 is a 4-bit CMOS μC that features 128-nibble RAM, 2k-nibble ROM, keypress interrupt, an 8-bit timer/event counter, an 8-bit serial interface, ac zero cross detection, low-voltage reset/watchdog timer, direct LED drive, 10-bit 6-channel ADC with a 33-μsec conversion time, and an OTP option. $1.99 (30,000). **Panasonic Semiconductors,** Elgin, IL. Phone (708) 468-5715. **Circle No. 416**

Local bus SCSI processor. The ISP1010 SCSI processor connects to a VESA, PCI, Intel 386DX, 486, or i960 local bus. A general-purpose RISC μP handles I/O control blocks, thread management, queues, and data flow; a SCSI Executive Processor manages SCSI bus protocols. The RISC μP communicates with the host via a 16-bit instruction and data path. $85 (100). **Emulex Corp,** Costa Mesa, CA. Phone (800) 662-4471; (714) 662-5600. **Circle No. 417**

Notebook controller. The 82C463 single-chip notebook controller operates with Intel's new S-series 466 μPs. The chip handles Intel and the company's proprietary Sequencer power-management modes. Other features include 3 and 5V operation; 33-MHz clock speed; and support for Windows Advanced Power Management. $25 (10,000). **Opti Inc,** Santa Clara, CA. Phone (408) 980-8178. **Circle No. 418**



ECLinPS translators. Eight translating devices are available for the ECLinPS logic family: TTL to differential PECL, differential PECL to TTL with V_{BB}, dual TTL to differential PECL, dual differential PECL to TTL, TTL to differential, differential ECL to TTL with V_{BB}, 1:2 fanout differential PECL to TTL with V_{BB}, and differential PECL to TTL. $4.29 (1000). **Motorola Inc,** Mesa, AZ. Phone (602) 962-3410. Fax (602) 898-5020. **Circle No. 419**



16-kbit serial EEPROM. The ST24C16C is an I^{2}C bus-compatible serial EEPROM. The chip has a 2k × 8-bit organization, which is sectioned into eight blocks of 256 bytes. The chip has a minimum of 100,000 erase and write cycles. A write protection scheme allows the upper half of the array to be protected against spurious or unauthorized erase or write operations. $3.05 (1000). **SGS-Thomson,** Phoenix, AZ. Phone (602) 867-6259. Fax (602) 867-6102. **Circle No. 420**

JPEG coprocessor. The L64702 compresses and decompresses ¼-screen windows having 240 × 352 pixels at a full-motion video rate of 30 frames/sec. Utilizing a 10:1 compression ratio, the chip sends compressed data to a hard disk at 500 kbytes/sec over a 2 Mbyte/sec ISA bus. Alternately, the chip can process an 8.5 × 11-in. image having 300-dpi resolution. $65 (1000). **LSI Logic Corp,** Milpitas, CA. Phone (408) 433-8000. **Circle No. 421**

Programmable filter-equalizer chip. The ML6017 is designed for magnetic disk drives having capacities from 300 Mbytes to 2 Gbytes. You can digitally program the chip to filter variable-speed data streams from 9 to 48 MHz, such as those found in magnetic and optical disk drives that use zone-bit recording. A serial interface programs the chip. The chip draws 90 mA from a 5V supply. $5.95 (100,000). **Micro Linear Corp,** San Jose, CA. Phone (408) 433-5200. **Circle No. 422**

Test & Measurement Instruments

10-MHz arbitrary-waveform generator. The 5920 stores 16k data points and produces waveforms with 12-bit resolution and less than 0.1% voltage error. The maximum output voltage is 30V p-p, the rise time is 100 nsec, and the typical frequency error is below 0.01%. The unit also operates as a function generator, producing standard waveforms. It offers a variable duty cycle and produces gated and triggered waveforms as well as triggered, counted waveform bursts. $2995. **Kron-Hite Corp,** Avon, MA. Phone (508) 580-1660. Fax (508) 583-8989. **Circle No. 406**

Universal power analyzer. The PM3000A, whose basic error is under 0.05%, works on single- and 3-phase power systems. The unit's three galvanically isolated channels accept peak inputs of 0.2 to 2000V and 10 mA to 200A. On 3-phase systems, you can connect the analyzer from phase to phase or from phase to neutral. For testing motor drives, the unit accepts inputs from speed and torque transducers. The analyzer has a measurement bandwidth of 500 kHz. In two seconds, it can perform a harmonic analysis (to the 99th harmonic) on each phase and the neutral of a 3-phase system. $11,900. **Voltech Inc,** Ashland, MA. Phone (508) 881-7329. Fax (508) 879-8669. **Circle No. 407**

13-slot VXIbus mainframes with built-in frequency standards. Building a frequency standard into a VXI mainframe frees slots for VXI modules. The $9950 1261AE incorporates an oven oscillator stable to within 5 parts in 10^{10} per day. The $18,550 1261AR incorporates a rubidium standard stable to within 5 parts in 10^{11} per month. Both frequency sources produce 1, 5, and 10 MHz as well as 1 pulse/sec. Each can have as many as five buffered outputs. To avoid warmup drift, the mainframes include a jack for connecting a standby power source that can maintain power to the frequency standard at all times. Delivery, 12 to 16 weeks, ARO. **Racal-Dana Instruments Inc,** Irvine, CA. Phone (800) 722-3262. Fax (714) 859-2505. **Circle No. 408**

Secondary-cell test system. The 378 applies controlled charge/discharge sequences to secondary cells ranging in size from AAA through D. The system tests cells in groups of as many as 400. Each test sequence can include as many as 1188 phases. In each phase, the cells can be charged, discharged, or rested. The system includes a PC based on a 50-MHz i486DX2 CPU. $117,000 (50 cells) to $362,000 (400 cells). **Enlode Inc,** Orange Park, FL. Phone (800) 874-7729; (904) 264-4405. Fax (904) 264-4405. **Circle No. 409**

Bit-error-rate test set for DS3 systems. The $4895 battery-powered PF-47 monitors systems that communicate at the 45-Mbps CCITT DS3 rate. The automatically self-configuring unit simultaneously performs more than 70 measurements, and analyzes and tests out-of-service equipment as well as systems that are in service. The handheld unit runs for 10 hours in monitor mode and 65 hours in test mode from a single battery charge. The back-lit 16×4-character LCD lets you use the tester in dimly lit areas. **Wandel & Goltermann Technologies Inc,** Morrisville, NC. Phone (800) 277-7404. **Circle No. 410**

Thermal-imaging system. The IQ812 is a real-time, radiometric infrared imaging system. It is sensitive to wavelengths of 8 to 12 μm and can resolve 240 lines of 348 elements per line. Sensitivity is 0.06°C at temperatures near ambient. The operator interface features pull-down menus. Display modes include pan, scroll, and zoom. You can also select up to five temperature cross-point displays as well as isothermal displays. From $59,500. **Flir Systems Inc,** Portland, OR. Phone (503) 684-3731. Fax (503) 684-5452. **Circle No. 411**

IEEE-488 buffer/monitor. The 4898 speeds the operation of IEEE-488-interfaced printers and plotters by buffering files as large as 4 Mbytes. The unit accepts data at 600 kbytes/sec and sends them to the graphical output device at a slower rate. As a bus monitor, the unit stores 2M 16-bit transactions. An MS-Windows program helps you interpret the stored data by displaying command mnemonics and interpretation notes. The unit is compatible with IEEE 488.2, and its commands conform to the SCPI syntax. $795 with 1 Mbyte of storage; $995 with 4 Mbytes. **ICS Electronics Corp,** Milpitas, CA. Phone (408) 263-5500. Fax (408) 263-5896. **Circle No. 412**

Multimode OTDR. The FCS-102D ISA bus card operates in three modes: as an optical time-domain reflectometer (OTDR) at a wavelength of 1310 nm, as an automated fault finder, and as a break finder with 1-button control. The board measures attenuation and return loss at the touch of a single button. Tests take less than three minutes. The unit, which works with optical-fiber cables as long as 40 km, exhibits a 5m dead zone. $10,000; delivery, 6 weeks, ARO. **Exfo EO Engineering Inc,** Vanier, Quebec, Canada. Phone (418) 683-0211. Fax (418) 683-2170. **Circle No. 413**

Test system for erbium-doped fiber amplifiers. The 81600 Series 200 system includes a tunable laser source with a built-in attenuator, optical power meter, optical amplifier test set, optical spectrum analyzer, Unix-based computer, and specialized software. The vendor's VEE icon-based software simplifies the creation of custom tests. Measurement repeatability is within 0.1 dB. The system makes 4 measurements/sec. Approximately $200,000. Deliveries begin in August 1993. **Hewlett-Packard Co,** San Jose, CA. Phone (800) 452-4844. **Circle No. 414**

100k-sample/sec board for laptop PCs. The half-length 4-channel UEI-127 draws all its power from the PC's 5V rail. An on-board dc/dc converter pro-

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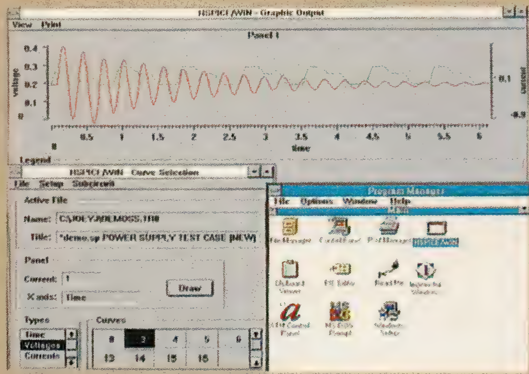

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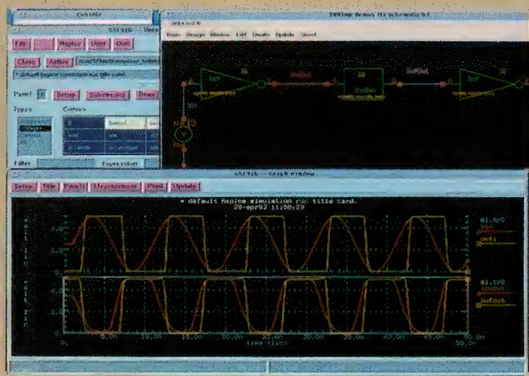
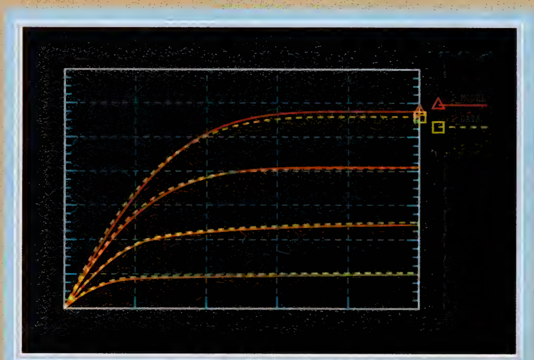


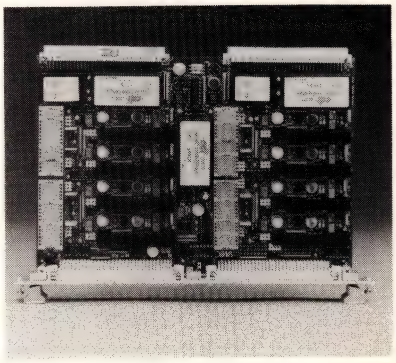
META MANAGER WITH CADENCE COMPOSER SCHEMATIC LINK



NEW BSIM 3 AND EPFL MODELS INSTALLED

vides the other supply voltages the board needs. The card's internal clock runs from 0.001 Hz to 50 kHz, but the card also accepts an external clock and allows programmable clock-frequency division. The card features simultaneous sample-and-hold analog inputs; sample-timing uncertainty is 4 nsec. The board also has two 12-bit DACs and 16 digital I/O lines. Drivers that work with seven MS-DOS languages accompany the board, along with C source code for the drivers and a stand-alone data-acquisition program. $595. **United Electronic Industries,** Watertown, MA. Phone (617) 924-1155. Fax (617) 924-1441. **Circle No. 415**

VMEbus signal conditioner for strain gages and RTDs. The VMIVME-3418 provides excitation and signal conditioning for eight resistance temperature detectors (RTDs) or strain



gages. One board accepts transducers of both types. Each group of four channels withstands 1 kV to the other group and to the VMEbus. You can order the board with constant-current or constant-voltage excitation. The constant current is programmable from 1 to 70 mA; there are three constant-voltage ranges from 2 to 12V dc. Headers accommodate full, half, and quarter strain-gage bridges and 2-, 3-, and 4-wire RTDs. $2129. **VME Microsystems International Corp,** Huntsville, AL. Phone (800) 322-3616; (205) 880-0444. Fax (205) 882-0859. **Circle No. 416**

Computer-upgrade package for GR275X board-test systems. This computer upgrade equips the vendor's GR2750, 2751, and 2752 with the same Sun Microsystems SPARCstation used in the GR2756 system. The SPARCstation replaces the Sun 3/80 used in the earlier-model testers. The vendor claims that the upgrade increases the speed of the test tools by an average of seven times. $99,000 including installation. **GenRad Inc,** Concord, MA. Phone (508) 369-4400. **Circle No. 417**

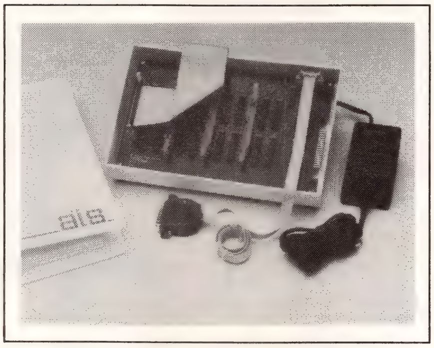
Extender board for SBus plug-ins. The SBus XB2-P/R uses a multilayer design to maintain a signal impedance of close to 75Ω. Each bus signal appears on a clearly labelled test point. Versions are available to extend the board under test parallel to the SPARCstation and at 90° to it. $195. **Dawn VME Products Inc,** Fremont, CA. Phone (800) 258-3296; (510) 657-4444. Fax (510) 657-3274. **Circle No. 418**

IEEE-488 data-acquisition software. GPIBLab is a software module that works with the vendor's DADisp, a spreadsheet-like, PC-based graphical data-analysis package. The GPIBLab module lets you set up IEEE-488 in-

struments and collect data from them without leaving DADisp. $495 including an ISA bus IEEE-488 controller board. **DSP Development Corp,** Cambridge, MA. Phone (617) 577-1133. Fax (617) 577-8211. **Circle No. 419**

$129, 8-channel data-acquisition board. You can configure the half-slot ANA201 to work in 8- or 16-bit ISA bus slots. The 12-bit board is available with conversion times of 10 and 3 μsec. $129. **BSoft Software Inc,** Columbus, OH. Phone (614) 491-0832. Fax (614) 497-9971. **Circle No. 420**

Tool for scan testing nonscannable logic. The $1095 ScanBox Probe/128 is a 128-pin stimulus-and-response interface that works with the vendor's ProTest boundary-scan test-development systems. It uses boundary-scan parts to add control and visibility to traces and logic that are otherwise untestable using scan techniques. The interface's test pins connect to the target board's inputs and outputs via connectors or test probes. When so connected, a tar-



get board is surrounded by virtual scan cells. The test systems, which cost $7995 to $30,000, can accommodate multiple interfaces to test high-pin-count assemblies. **AIS,** Los Altos, CA. Phone (415) 941-3247. Fax (415) 941-7642. **Circle No. 421**

DSO plug-ins. The $31,400 54710D and the $45,900 54720D are 2- and 4-channel deep-memory mainframes in the vendor's very-high-performance color-display DSO family. The $9950 54722A is a quadruple-width plug-in that takes 8G samples/sec on one channel in real time and, when used in the 54720D, provides a bandwidth of 2 GHz. The plug-in samples 4× as fast as any other commercial real-time-sampling DSO and offers 4× the single-shot bandwidth. The 54720D offers 64k samples/channel of display memory or 256k samples with the quadruple-width 54722A. Delivery range, from 4 to 10 weeks, ARO. **Hewlett-Packard Co,** Santa Clara, CA. Phone (800) 452-4844. **Circle No. 422**

Manufacturing-defects analyzer. Each guard circuit of the 2048-point (max) MAX2-1000 can supply 100 mA to components connected to the node under test. The system's automatic-program-generation software downloads netlist and parts-list information from your automated design system. You can develop board-test programs on the system itself or off line on an 80386- or i486-based PC. The program-generation software automatically locates guard pins. A 128-point system costs $27,955; additional groups of 64 points cost $1985. **Digalog Systems Inc,** New Berlin, WI. Phone (414) 797-8000. Fax (414) 797-8003. **Circle No. 423**

EDN-NEW PRODUCTS

Components & Power Supplies

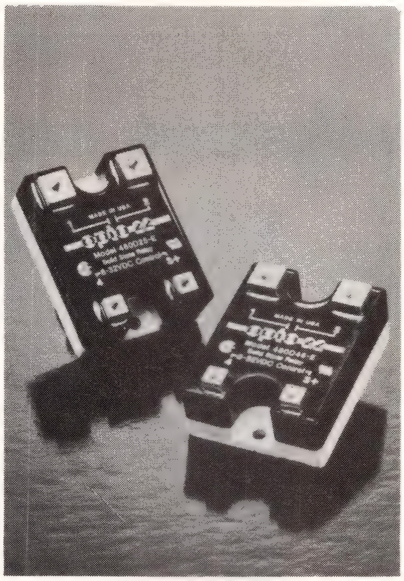
Shielded connectors. The 3359 Series 50-position, D-ribbon interconnect system consists of four components. The first is a 50-position SCSI- and SCSI II-approved, metal-faced ribbon connector that accepts 0.050-in. pitch cable. Also part of the system are inner and outer crimp sleeves, a metal junction shell for EMI/ESD grounding, and a plastic molded boot that fits over the metal junction shell after termination is complete. $6.23 (1000). **3M Electronic Products Div,** Austin, TX. Phone (800) 225-5373; (512) 984-3897.
Circle No. 530

PC-board connectors. FCN720M Series IDC sockets and fully shrouded headers are available in 20-, 26-, 34-, 40-, 44-, and 50-position versions. The connectors feature a 2-mm pitch and will terminate a flat cable that has a 1-mm conductor pitch. Headers are available in straight, right-angle, and surface-mountable versions. The sockets feature bump polarization to prevent reverse insertion. Contacts are rated for 1A at 250V ac and have a 20-mΩ contact resistance. Operating range spans −55 to +105°C. A 44-position socket, $2.65 (1000). **Fujitsu Microelectronics Inc,** San Jose, CA. Phone (800) 642-7616; (408) 922-9000. Fax (408) 428-0640.
Circle No. 531

Panel connectors. Lite wire-trap connectors feature a vertical orientation that eases the task of inserting and removing stripped wire. A built-in alignment shelf orients the connector to the user's mounting panel. Mounting pegs provide board-level polarization. The connectors are UL and CSA listed, are compatible with robotic board-loading equipment, and accommodate 16 to 20 AWG wire sizes. The phosphor bronze contacts feature tin plating, and the housings carry a 94V-0 UL rating. From $0.345 (100,000). **Molex Inc,** Lisle, IL. Phone (708) 969-4550. Fax (708) 969-1352.
Circle No. 532

Power-fail monitor. The Model PF-VME autoranging module monitors the ac line and the 5V logic output in VME systems. The unit is powered by ac and dc input signals. When both the ac and dc signals are above thresholds, the module asserts an ACFAIL signal followed by a SYSRESET signal in accordance with VME timing specifications. If either input signal drops below threshold levels, the output signals become disasserted. The threshold ranges can be set from 85 to 110V ac or 170 to 220V ac and from 4 to 5V dc. $60 (OEM qty). **Deltron Inc,** North Wales, PA. Phone (215) 699-9261. Fax (215) 699-2310.
Circle No. 533

Transient suppressors. HSMC Series suppressors are housed in surface-mountable, hermetically sealed ceramic packages. Key features include a 1500W pk power dissipation, a 1-psec theoretical response time, 5-μA reverse leakage current, and a −55 to +175°C operating range. The units are available with reverse standoff voltage ratings of 5 to 200V and with clamping factors of less than 1.3. The units are available with gull-wing or J-lead type terminations. $8 (5000). **ProTek Devices,** Tempe, AZ. Phone (602) 968-6060. Fax (602) 921-3760.
Circle No. 534



Solid-state relays. Models 480D25E and 480D45E solid-state relays handle loads of 480V at 25 and 45A, respectively. Both devices feature a 1200V peak repetitive voltage rating. Both devices also feature 4000V isolation, a zero-voltage turn-on, built-in snubber, and a rugged encapsulated package with a die-cast mounting base. Operating range spans −40 to +100°C. 480D25E, $13; 480D45E, $20 (250). **Opto 22,** Temecula, CA. Phone (800) 321-6786; (714) 695-9299. Fax (714) 695-2712.
Circle No. 535

MOSFET. The RFP70N03 N-channel MOSFET has a 30V breakdown rating, a 70A current carrying capability, and an 80-nsec max turn-on time. Maximum operating junction temperature rating equals 175°C. Gate threshold voltage ranges from 2 to 4V, and zero-gate voltage-drain current measures 1 μA max. Output capacitance equals 1750 pF. $4.05 (1000). **Harris Semiconductor,** Melbourne, FL. Phone (800) 442-7747; (407) 724-3704.
Circle No. 536

Boost converter. The VUM24-05N module consists of a single-phase ac/dc bridge, a 500V 120-mΩ MOSFET, and a 600V/30A ultrafast reverse recovery diode connected for use as a boost converter circuit. The module is rated for operation over a universal input range of 85 to 265V rms and can control as much as 2.5 kW in 230V applications and 1.2 kW at 120V. The module housing measures 1.25×2.5×1 in. and features an isolated mounting baseplate. $24.48 (100). **IXYS Corp,** San Jose, CA. Phone (408) 435-1900. Fax (408) 435-0670.
Circle No. 537

Power transistor. The MRF880 UHF linear device suits cellular base stations. The unit is a class AB device that features a 90W power output and a 9.5-dB typ gain across a frequency range of 800 to 960 MHz. The unit features silicon nitride passivation and gold top metal and emitter ballasting. Efficiency equals 35% min at 900 MHz, and intermodulation distortion measures −29 dBc max. $246. **Motorola Inc,** Phoenix, AZ. Phone (602) 244-3818. Fax (602) 244-4597.
Circle No. 538

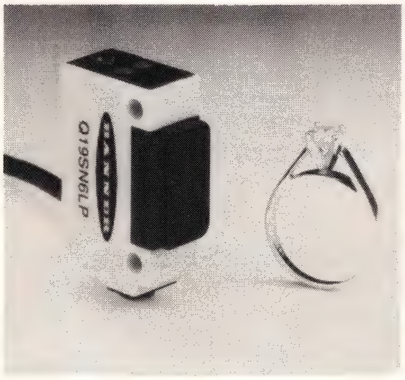
Clock oscillators. The surface-mount AMO-HC Series clock oscillators drive 10 TTL gates or 50-pF CMOS loads. The units are available in frequencies ranging from 1.5 to 50 MHz with stabilities of ±100 ppm over a 0 to 70°C range. The units feature a built-in decoupling capacitor to reduce power-supply line noise. Symmetry of 45/55 is standard in all oscillators; a 3-state enable-disable feature is available as an option. $2.75 (1000). **AVX Corp,** Myrtle Beach, SC. Phone (803) 946-0263. Fax (803) 448-1943.
Circle No. 539

Stacking connector. This shielded parallel stacking connector uses Cin::Apse button contact technology. The 5-row 0.05-in.-pitch interstitial con-

tact pattern permits 249 connections in a space of less than 1 in.^{2}. The connector is available in heights of 0.277, 0.733, and 0.933 in. The addition of chipper shielding yields a system that can support data rates in the 250-MHz range. \$20 to \$60. Delivery, four to six weeks ARO. **Cinch Connectors,** Elk Grove Village, IL. Phone (708) 981-6000, ext 6179. **Circle No. 540**

Optocouplers. ILH100 and ILH200 phototransistor optocouplers are hermetically sealed to keep out moisture. Both optocouplers have ceramic packaging and operate over a −55 to +125°C range. Both devices offer current transfer ratios of 100 to 500% and power dissipation ratings of 350 mW. The ILH100 features a single optocoupler in an 8-pin DIP; the ILH200 contains two optocouplers in an 8-pin DIP. ILH100, \$11.88; ILH200, \$13.75 (5000). **Siemens Components Inc,** Santa Clara, CA. Phone (408) 980-4500. **Circle No. 541**

Photoelectric sensor. The Q19 photoelectric sensor operates from a 10 to 30V supply and has a sensing range of 2 to 80 in. The unit includes an alarm feature and NO and NC outputs. Each output can handle 150-mA loads. The



complementary output scheme lets one output signal a controller or sound an alarm whenever sensing conditions become marginal. The unit comes with a dual-LED top-panel indicator system to inform the operator of sensing conditions such as power-on, output overload, object sensed, and low gain. \$75. **Banner Engineering Corp,** Minneapolis, MN. Phone (612) 544-3164. **Circle No. 542**

VMEbus enclosure. The MSE 12-slot VMEbus enclosure includes a 600W power supply that features power factor correction. The unit's J1 and J2 backplanes comply with the IEEE-P1014 specification. The backplane features a sealed monolithic, multilayer, fully laminated construction. Power and ground are implemented via a bus bar that ensures consistent voltage levels throughout the system. The enclosure provides mounting space for three half-height storage devices (two 3½ in. and one 5¼ in.). Cutouts are provided for connectors on the back panel. \$3995. **Heurikon Corp,** Madison, WI. Phone (800) 356-9602; (608) 831-0900. Fax (608) 831-4249. **Circle No. 543**

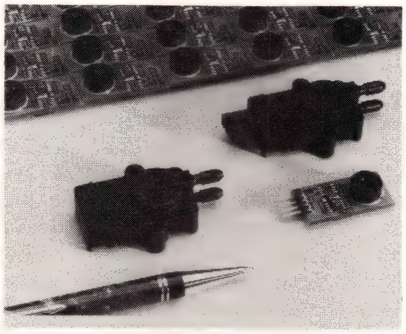
Enclosure. Designed for Futurebus+ systems, the FB02 Series unit is a 19-in. rackmount design that incorporates horizontal card loading. Fully compliant with 896.2 requirements, the enclosure incorporates a power supply that can be configured to develop 1600W with a 230V input or 1200W with a 115V input. The front of the enclosure includes a hinged front panel and an LED display area for ac on, voltage indicators (5, 2.1,

CIRCLE NO. 102

3.3, 12, and 48V), and overtemperature indication. From $8777. **Hybricon Corp,** Ayer, MA. Phone (508) 772-5422. Fax (508) 772-2963. **Circle No. 544**

DC/DC converters. CQ family 100W converters accept inputs of 38.4 to 75V and provide outputs of 5.1, 12, 15, 24, 30, 48, ±12, ±15, or ±24. The units will slide into a 3U VME rack without additional engineering; as many as 16 units will fit into a standard 19-in. rack. The supplies are also chassis mountable. The units feature true current sharing 1in parallel operation, temperature and voltage limits, protection circuitry, remote on-off, voltage trimming, power OK signals, and no minimum load requirements to maintain regulation. From $380 (100). **Melcher Inc,** Chelmsford, MA. Phone (800) 828-9712; (508) 256-1812. Fax (508) 256-4642. **Circle No. 545**

Pressure transducer. NPS Series smart transducers feature a compensated output signal in addition to 1% interchangeable calibration over an operating range of −20 to +85°C. Thermal-accuracy offset and full-scale output accuracy equal 1% max, and linearity error measures ±0.2% of full-scale output over the full operating range. The devices operate from a 5V supply and



are available in a 0 to 15 psiA measurement range. $30 (1000). **Lucas Novasensor,** Fremont, CA. Phone (510) 490-9100. Fax (510) 770-0645. **Circle No. 546**

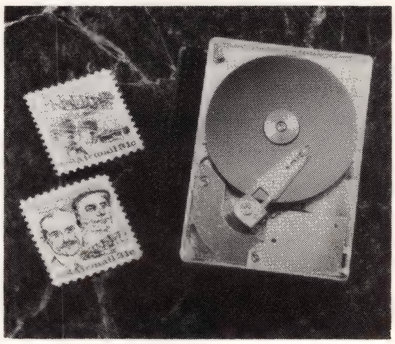
Preamplifier. Model LN1000 operates over a 10-kHz to 1000-MHz bandwidth and offers a combination of 3.5-dB-typ noise, and a 30-dB-min gain. With a −18-dBm input signal, output power equals 11 dBm at less than 1-dB compression. Harmonic distortion is −20 dBc max at rated output. Power is supplied by an external 12V supply that plugs into any 120/240V ac outlet. BNC connectors are supplied for the input and output. $700. **Amplifier Research,** Souderton, PA. Phone (800) 933-8181; (215) 896-9260. Fax (215) 723-5688. In UK, phone (0908) 566556. **Circle No. 547**

Shielding. Microgrid is a flexible, lightweight, mesh-like material produced from a solid sheet of metal foil. Its single-unit structure provides superior shielding and conductivity by eliminating the unraveling and contact resistance found in woven mesh. The standard material is flat; when it is pulled lengthwise, 3-D pockets are created in the diamond shaped open areas. These pockets accept coatings or laminates and add depth to the product. Pricing by custom quotes; delivery, four to six weeks ARO. **Delker Corp,** Branford, CT. Phone (203) 481-4277. Fax (203) 488-6902. **Circle No. 548**

Computers & Peripherals

PC disk drives. The ST3290A and ST3390 hard-disk drives target the entry- to mid-level and high-end PC markets, respectively. The lower-end ST3290A stores 260 Mbytes of data and has an average seek time of 16 msec; the higher-end ST3390 stores 340 Mbytes and has a seek time of 12 msec. The former has a 64-kbyte adaptive cache; the latter has a 256-kbyte cache. The ST3390's average latency of 6.67 msec results from a 4500-rpm spindle rotation speed. It transfers data at 10 Mbytes/sec. ST3290A, $500; ST3390, $600. **Seagate Technology,** Scotts Valley, CA. Phone (408) 438-6550. **Circle No. 437**

Networked photo CD recorder. The Netscribe 1000, based on the Kodak PCD Writer 200, lets network users write to recordable CDs. It appears as a network resource to client users, letting them transfer selected directories and files to CD through an intuitive drag-and-drop graphical interface. The system creates CD-ROMs in ISO 9660 format; CD device- and format-dependencies are transparent to the user. $13,995. **Meridian Data Inc,** Scotts Valley, CA. Phone (408) 438-3100. Fax (408) 438-6816. **Circle No. 438**



1.3-in. disk drive. The Kittyhawk II, a 1.3-in. hard-disk drive, has twice the storage capacity of its predecessor, plus better power management and increased durability. The 42.5-Mbyte drive weighs less than 1 oz (28 g) and measures $2 \times 1.44 \times 0.4$ in. ($50.8 \times 36.5 \times 10.5$ mm). Its 10.5-mm thickness qualifies it for inclusion in PCMCIA Type III modules. The drive operates at 5V. Power consumption is 1.5W for read operations, 1.7W for writing, and 15 mW in sleep mode. Spinup consumes 2.8W and takes approximately 1 sec. Shock tolerance of the drive is 150G while operating and 300G when not. $499. **Hewlett-Packard Co,** Santa Clara, CA. Phone (800) 826-4111. **Circle No. 439**

Optical disk drives. Two new 3.5-in. magneto-optical (MO) drives, the Transporter1 and the Transporter2, each store 128 Mbytes of data on removable cartridges. The Transporter1 emphasizes low price; the Transporter2 stresses performance. Transporter1 has 1800-rpm speed and a 64-kbyte data dual-port buffer; Transporter2 runs at 3000 rpm and has a 256-kbyte buffer. The Transporter1 is for internal installation; the Transporter2 is available for internal installation or as an external subsystem. Both drives have a SCSI interface. Transporter1, $1685; Transporter2, $1985. **Ricoh Corp,** San Jose, CA. Phone (800) 955-3453. Fax (408) 943-9364. **Circle No. 440**

Wireless LAN adapter. RangeLAN/PCMCIA is a wireless LAN adapter that works in PCMCIA Type II sockets. It's available with drivers for most popular networks, including Novell NewWare 3x, NetWare Lite, and Microsoft Windows for Workgroups. The device uses spread-spectrum RF technology that does not require FCC licensing. Its indoor range is 300 to 500 ft; outdoors or in large, open warehouses, the range is 800 to 1000 ft. $595. **Proxim Inc,** Mountain View, CA. Phone (415) 960-1630. Fax (415) 964-5181. **Circle No. 441**

Panel-mount industrial computer. A new PC/AT-compatible industrial computer combines a flat-panel display, a 486SLC-based computer, and an infrared touch screen. The front portion of the panel-mount system is sealed to meet the requirements of NEMA 4 and 12. A door, which seals when closed, covers a 1.44-Mbyte floppy-disk drive and a reset switch. The system also comes with a 120-Mbyte hard disk. You can choose either an active-matrix color LCD or a monochrome EL display. With monochrome display, $6080 (OEM). **Lucas Deeco,** Hayward, CA. Phone (510) 471-4700. Fax (510) 489-3500. **Circle No. 442**

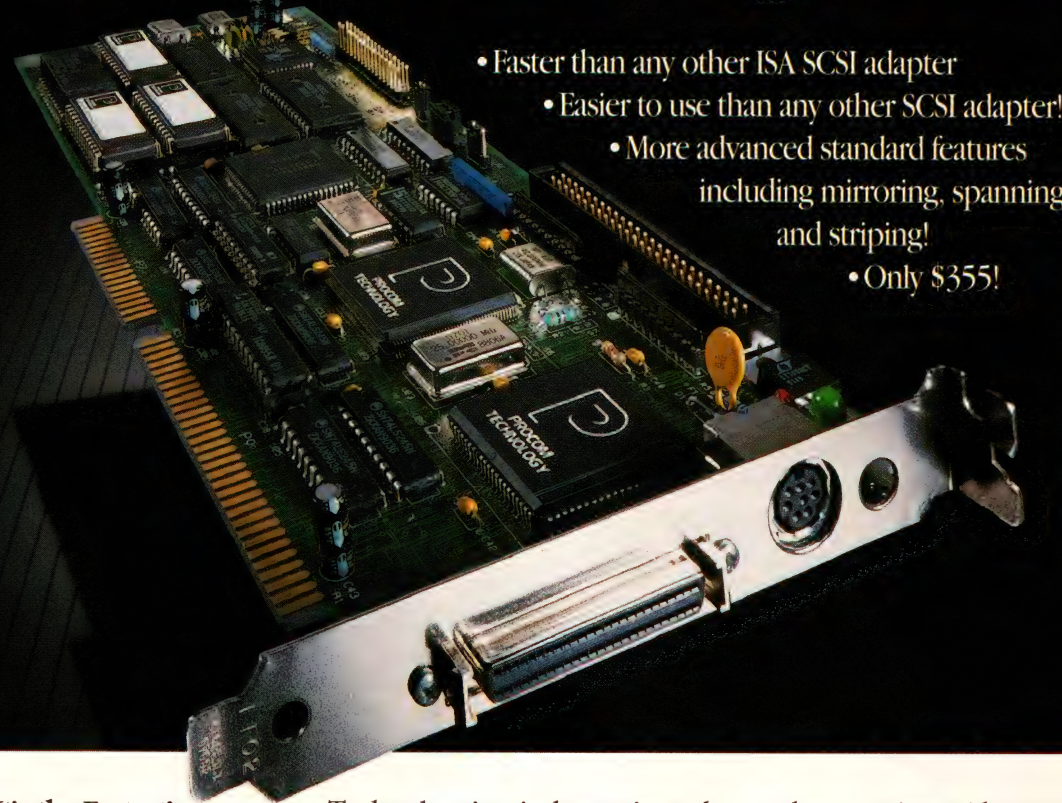
PA-RISC workstation. The SWS715 workstation, based on Hewlett-Packard's PA-7100 superscalar processor with an on-chip floating-point coprocessor, provides 69 SPECmark89 at 50 MHz. Its integer performance is 36 SPECint92; floating-point performance is 72 SPECfp92. The workstation is also available in a less expensive 33-MHz version. Both run the manufacturer's SS-UX operating system, which is binary compatible with the HP-UX OS. Prices start at $3995 for a 33-MHz entry-level configuration with 8 Mbytes of memory and no disk or monitor. A standard configuration of the 50-MHz model with a 19-in. color monitor, 16 Mbytes of RAM, and a 525-Mbyte hard disk costs $13,995. **Samsung Electronics Co Ltd,** San Jose, CA. Phone (408) 434-5437. Fax (408) 434-5454. **Circle No. 443**

PCMCIA SRAM cards. Three new PCMCIA SRAM cards have capacities of 512 kbytes, 1 Mbyte, and 2 Mbytes. They use lower-power chips that are backed up by a lithium battery. They have an indicator for low battery power and a built-in write-protect switch. The manufacturer claims testing confirms 10,000 insertions. 512 kbytes, $329; 1 Mbyte, $499; 2 Mbytes, $799. **Verbatim Corp,** Charlotte, NC. Phone (704) 547-6783. **Circle No. 444**

DSP-based signal processor. The HEXC31, a 6U VME board, provides 240-Mflops peak processing using six Texas Instruments 40-MHz DSP chips. The six processors share 16 Mbytes of global memory, which is organized into four banks to reduce the board's power consumption to 30W. Each processor also has 512 kbytes of dedicated zero-wait-state SRAM. For embedded applications, the HEXC31 can process either multiple channels of independent data or a single channel with very high bandwidth. $12,995. **Analogic Corp,** Peabody, MA. Phone (508) 977-3000, ext 3441. Fax (508) 977-9220. **Circle No. 445**

Graphics controller for VMEbus. The B301 graphics controller for VMEbus displays 256 colors (from a palette of

ISA Xelerator.™ The New Standard For SCSI Host Adapters.



- Faster than any other ISA SCSI adapter
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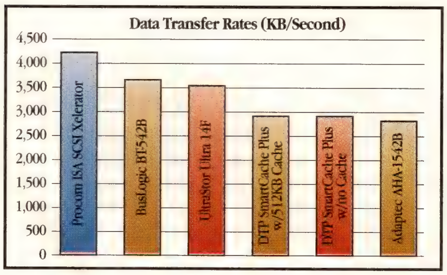
It's the Fastest!

The Xelerator gives you a FAST SCSI-2, 10 megabytes per second data transfer rate. Our fast 16MHz processor reduces request processing time and you can fine tune the transfer rate to optimize the performance of CD-ROMs, DAT drives, MODs, scanners, removable media or any SCSI device.



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Configuring a disk system has always been a chore, but not with the Xelerator! With Procom Technology's window-oriented setup and configuration screens, you'll be configured and ready to operate in minutes—not hours. Instead of 20 to 50 configuration jumpers, the Xelerator has five. Maintenance and re-configuration are just as simple. The Xelerator is easy enough for a beginner, yet still has the performance and features the advanced user needs.

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But the best news is you can get the Xelerator at no more cost than ordinary SCSI host adapters—it retails for just **$355.**

There's so much more we want to tell you about the Xelerator, including how you can get one. For more information, or the location of a dealer in your area, just call Procom Technology at **1-800-800-8600**.

PROCOM TECHNOLOGY

2181 Dupont Drive, Irvine, CA 92715
714-852-1000; FAX: 714-852-1221
International FAX: 714-261-7456

CIRCLE NO. 125

16 million) in a format of 1024×768 pixels. Optionally, software can set the format to 640×480. The board has 1 Mbyte (optionally 2 Mbytes) of dual-port video memory. On the VMEbus, the B301 behaves as an A24/D16 slave/interrupter. The 3U board can work in 6U systems by fitting a 6U front panel to it. DM 825 (approximately $525 US). **MEN Mikro Elektronik,** Nurnberg, Germany. Phone (0911) 99335-0. Fax (0911) 99335-99. **Circle No. 446**

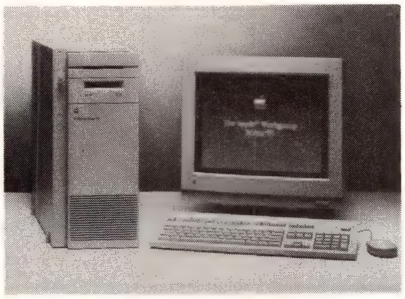
Touch-screen kiosk system. The ServiceTouch Kiosk is a fully integrated, self-service kiosk with a touch-screen interface. It includes a 486-based computer, a printer, speakers, and a credit-card reader. Because it may see use in unattended public environments, the kiosk has a vandal-proof steel case with rugged front and back plastic panels and security locks. The kiosk also includes a cooling system and a conditioned power supply. $5695. **Micro-Touch Systems Inc,** Wilmington, MA. Phone (508) 694-9900. **Circle No. 447**

High-end color monitor. The IntelliColor Display/20, a 20-in. Trinitron-based display system for high-end color applications, provides bidirectional communication between the µP-controlled display and a computer, thus allowing easy and precise control of geometry, image size, centering, and color temperature. Refresh rates can be as high as 160 Hz with resolution up to 1600×1200. The system comes with software that simplifies control. $3199. **Radius Inc,** San Jose, CA. Phone (408) 434-1010. Fax (408) 434-0770. **Circle No. 448**

Flicker-free color monitor. Users of the Pixelink 120XDS Windows and Unix/X document-display systems can now use a 21-in., flicker-free monitor. The new monitor provides a 76-Hz refresh rate and 120-dpi resolution. $2000. **Pixelink Corp,** Hudson, MA. Phone (508) 562-4803. Fax (508) 568-0514. **Circle No. 449**

Stereo audio boards. The AudioMax Series of stereo audio multiplexing and processing boards lets you control processing and mixing of stereo audio from multiple sources, including volume, tone, and stereo effects on your PC. The boards allow audio multiplexing with configurations having 2 to 18 stereo inputs, 1 to 6 stereo outputs, and up to 6 digitally controlled audio processors. From $795. **MaxMedia Inc,** Lake Bluff, IL. Phone (708) 234-8840. **Circle No. 450**

386SX PC on 3U Eurocard. The GESSBS-38 provides a 25-MHz 80386SX and VGA graphics on a single-height Eurocard. All connections to the board go through two high-density, 50-pin connectors to a front-panel module that has the standard DIN, DB-9, and DB-25 connectors found on all PCs. The board is expandable through its G-96 bus interface to I/O modules. It comes with 2 or 8 Mbytes of RAM. With 2 Mbytes, $1450. **Gespac Inc,** Mesa, AZ. Phone (602) 962-5559. Fax (602) 962-5750. **Circle No. 451**



Servers for Macintosh workgroups. Three new servers—Workgroup Server 60, 80, and 95—serve workgroups that consist primarily of Apple Macintosh users. Server 60 is an entry-level file and print server; Server 80 adds communications; Server 95 provides relational database-management services. All are based on the Motorola 68040 µP; they run enhanced versions of AppleShare. Server 60 with 230-Mbyte hard disk, $3079; Server 80 with 500-Mbyte disk, $6399; Server 95 with 500-Mbyte disk, $10,039. **Apple Computer Inc,** Cupertino, CA. Phone (408) 996-1010. **Circle No. 452**

PC stereo sound board. The Series 2/Model SX-7 stereo sound board plays broadcast-quality stereo sound through PCs and PS/2 computers. Designed to be a low-cost distribution device for Dolby AC-2, the board also supports ADPCM, PCM, DVI, and CD-ROM XA/CDI. Files compressed with Dolby AC-2 take one-sixth the space of uncompressed files and can be transmitted over T-1 phone lines. $995. **Antex Electronics Corp,** 16100 S Figueroa St, Gardena, CA 90248. Phone (310) 532-3092. **Circle No. 453**

The EDN BBS

The EDN Reader's BBS (Bulletin Board System) combines both the point-to-point communication of e-mail with the saturation coverage of broadcasting. In addition to sending and receiving text messages, BBS users can also exchange any form of computerized material.

The EDN Readers' BBS is completely free and noncommercial. All new users have full privileges immediately. The BBS has no time limits, download limits, upload requirements, or user fees.

EDN editors use the BBS several ways to communicate with readers. First, any EDN story or Design Idea that has computerized material associated with it will have a copy of that material posted on the BBS. This procedure saves readers the effort and errors that come with typing in a program manually. Further, editors can post corrections or additions to stories immediately on the BBS instead of waiting to print them in EDN.

The BBS serves as a 24-hour/day electronic conference where readers can share opinions, problems, and solutions with their peers. Readers can pose questions on a public BBS forum that parallels EDN's popular Ask EDN column. In addition to posing questions, readers can also post answers to other readers' questions on the Ask EDN forum.

Editors and readers can exchange private messages and computer files using the BBS's e-mail facility. EDN's BBS contains over 1500 engineering-related programs; some are "public domain" (free) and some are "shareware" (software that can be tried out for free and paid for on the honor system).

To Log On

To log on to the EDN Readers' BBS, set your modem for 1200/2400 baud (8,N,1) and dial (617) 558-4241.

CAE & Software Development Tools

Spice circuit simulator. The T-Spice circuit simulator provides a table-based model evaluation option that speeds simulation for large digital and mixed digital-analog designs. The company claims you can simulate designs with over 200,000 circuit elements using the software. You can generate the tables from the included analytical models, from your own analytical models, or from experimental data. The software comes with standard Spice models, and you can write models for custom components in the C language. The software is available for PCs and Sun and HP workstations. Prices start at $1245 for T-Spice with the advanced model library and a waveform viewer. **Tanner Research,** Pasadena, CA. Phone (818) 792-3000. Fax (818) 792-0300.
Circle No. 454

Pentium simulation models. Hardware and software simulation models for Intel's Pentium microprocessor simplify board- and system-level simulation. A full-functional hardware model uses the actual Pentium processor in the simulation, enabling the model to accurately represent all device functions, including undocumented behavior. The hardware model is $8000 and requires Logic Modeling's hardware model server. A bus-functional behavioral model provides all bus cycles but uses a specialized bus-control language instead of the processor's standard instruction set to control the model. The software model is $15,000 with a $2250 per year maintenance option. **Logic Modeling,** Beaverton, OR. Phone (800) 1344-0004. **Circle No. 455**

Simulating switch-mode power supplies. A free newsletter from Intusoft describes models for switching converters including buck, boost, buck-boost, and Cuk topologies. Contact the company for a copy of its March newsletter. **Intusoft,** San Pedro, CA. Phone (310) 833-0710. Fax (310) 833-9658.
Circle No. 456

Verilog-XL integrated into Simview. Designers using Verilog-XL with Mentor Graphic's Falcon Framework now can use the graphical simulation interface and the interactive design debugging available with Simview. The interface will be made available through Mentor Graphics' OpenDoor program to let Verilog clone vendors also achieve the same level of integration. The software is $5000 and will be available in the third quarter for Sun and HP workstations. **Mentor Graphics,** Wilsonville, OR. Phone (503) 685-7000. Fax (503) 685-1202. **Circle No. 457**

CAE company integrates test-generation software. Viewlogic is integrating Sunrise Test Systems' test-automation software for ICs under its PowerView design environment. The new product, called ViewTest, comprises three modules: a fault simulator for measuring the fault coverage provided by the test vectors; an automatic test vector generator; and a test synthesis tool, which automatically modifies a design to improve testability. The software, available now, is $75,000 for designs up to 40,000 gates and $95,000 for an unlimited number gates. **Sunrise Test Systems,** Sunnyvale, CA. Phone (408) 739-4000. Fax (408) 739-4081.
Circle No. 458
Viewlogic Systems, Marlboro, MA. Phone (508) 480-0881. Fax (508) 480-0882. **Circle No. 459**

Signal-integrity consultant kit. Aimed at design engineers just pushing up against signal-integrity problems, the kit provides a selection of tools plus an educational videotape entitled "Glitches, Intermittents, and Noise: The Art of Noise Budgeting." Software tools include a limited time-domain transmission-line simulator, a Laplace field solver, a frequency-domain transmission-line program, and a time-domain crosstalk simulator. The kit is priced at $1295. **Integrity Engineering,** St Paul, MN. Phone (612) 636-6913. Fax (612) 631-2241. **Circle No. 460**

Stand-alone incremental linker. The PureLink linker replaces linkers that come with compilers. It reduces build times by 90% and provides diagnostics for any build-time errors. The software runs on SPARC computers and works with C and C++ compilers. $10,000. **Pure Software,** Sunnyvale, CA. (408) 720-1600. Fax (408) 720-9200.
Circle No. 461

Development software. The ProWorks tools for the 80x86 version of the Solaris operating system are now available. The ProWorks family comprises code-management programs and C, C++, and Fortran compilers. Debuggers, browsers, software-performance analyzers, and make utilities are also available. The code produced runs on 80x86 PCs under Solaris. Single-user prices range from $895 to $1095, depending on compiler. **SunPro,** Mountain View, CA. Phone (415) 960-1300. Fax (415) 969-9131. **Circle No. 462**

Decision-tree package. IND software from the University of Georgia's COSMIC program combines four basic decision-tree routines: data manipulation, tree-generation, tree-testing, and tree-display. The software is in C for Sun4 computers. IND, inventory number ARC-13188, $500 (¼-in. streaming tape); documentation, $20. **COSMIC,** Athens, GA. Phone (706) 542-3265. Fax (706) 542-4807.
Circle No. 463

Math software. Mathcad 4.0, a major upgrade, features a rules-based processor for numeric and symbolic calculations. The new version also performs 32-bit math on PCs and runs under Windows 3.1 and OLE (object linking and embedding). It runs twice as fast as earlier versions and supports large arrays. $495; upgrade to older versions, $49.99. **MathSoft Inc,** Cambridge, MA. Phone (617) 577-1017. **Circle No. 466**

Secure Ada development. The Ada/HP 9000/700 Ada development package runs on Hewlett-Packard 9000/700 workstations. The Ada compiler incorporates a language-sensitive editor and a symbolic debugger. The software meets HP's Softbench specs so that it can interface to third-party software. $7000. **Irvine Compiler Corp,** Irvine, CA. Phone (714) 250-1366. Fax (714) 250-0676. **Circle No. 465**

Math software. The Scientist program V1.0 runs on MS-DOS computers to solve linear and differential equations. It can handle 20 parameters, 100 equations, 100 dependent variables, and 16,384 data points. The software draws graphs and interfaces to common spreadsheets and databases. $495. **MicroMath,** Salt Lake City, UT. Phone (800) 942-6284; (801) 943-0290. Fax (801) 943-0299. **Circle No. 464**

Math for Windows. Mathematica 2.2 runs under Windows and includes over 2000 other improvements to earlier versions. In addition to offering 32-bit math, the program solves sparse linear systems and handles matrices faster than before. You can now make rigorous error estimates and solve nonlinear ordinary differential equations. The new version also runs on Macintosh and Sun computers. $595; upgrade to older versions, $50. **Wolfram Research Inc,** Champaign, IL. Phone (217) 398-0700. Fax (217) 398-0747. **Circle No. 467**

TCP/IP for Am29000 RISC μP. The Fusion 29K Developer's Kit provides TCP/IP source code with modular Am29000 (Advanced Micro Devices) and VRTX (Ready Systems) drivers for embedded systems. The processor interface, the operating-system (kernel) interface, and the physical interface are isolated from the main bulk of the protocol stack, simplifying porting. $15,000; FDDI (Fiber-Distributed Data Interface) driver, $2000. **Pacific Softworks,** Camarillo, CA. Phone (805) 484-2128. Fax (805) 484-3929. **Circle No. 468**

Real-time kernel. The Nucleus PLUS real-time kernel runs on 80x86 (real mode), 68xxx, and Am29000 μPs. Prices start at $5000 for source code; no charge for binary copies in a single product line. **Accelerated Technology Inc,** Mobile, AL. Phone (205) 661-5770. Fax (205) 661-5788. **Circle No. 469**

Test equipment and tool catalog. The 204-pg color catalog lists test equipment, tools, tool kits, and supplies from vendors such as Tektronix, Fluke, B+K Precision, and Leader Instruments. **Contact East,** North Andover, MA. **Circle No. 479**

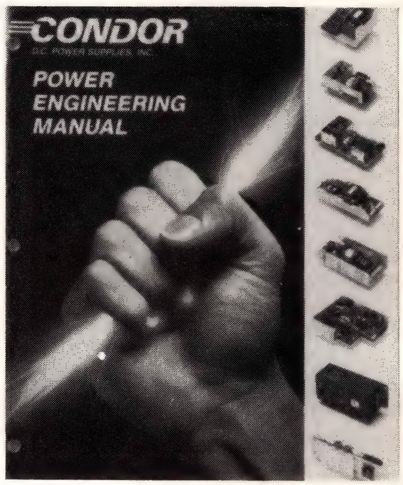
Catalog of IC test systems and peripherals. This 36-pg, full-color catalog describes the firm's testers for LSI and VLSI ICs, memory chips, and mixed-signal chips as well as electron-beam testers and device handlers. **Advantest America Corp,** Fort Lee, NJ. **Circle No. 480**

Ceramic capacitors catalog. Catalog C-01-D provides detailed data on monolithic ceramic capacitors. Included are

a variety of chip devices in sizes ranging from EIA 0603 through 2225. The catalog also includes data on a broad selection of leaded ceramic capacitors. Ceramic-capacitor definitions are also included, as are packaging, environmental, mechanical, and application details. **Murata Erie North America,** Smyrna, GA. **Circle No. 481**

Multibus II directory. The 1993 edition of the Multibus II Product Directory lists products and services in 10 categories from numerous companies. Six of the categories are boards: CPU, communications, peripheral controller, digital/analog I/O, memory, and development. Other categories are components and accessories, systems and software, and consulting and dealer services. $24.95. **Multibus Manufacturers Group,** Aloha, OR, and Ross-Shire, UK. **Circle No. 482**

Power-supply catalog. This 60-pg catalog covers a range of models, including linear and switching units in both open and enclosed versions. More than

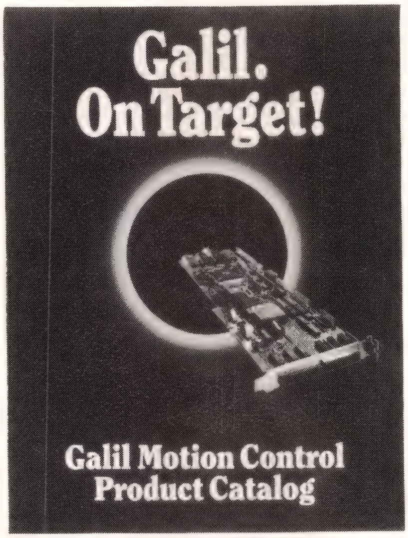


280 single- and multiple-output models are included, and each product category includes complete features and specifications, ratings, and mechanical drawings. **Condor Inc,** Oxnard, CA. **Circle No. 483**

Industrial-computer catalog. Catalogue 5 is a source for application and technical data on Arcom's VMEbus and

STEbus computer modules and software. It presents product information in six different categories and also describes new products introduced since the publication of Catalogue 4. The catalog also lists application notes that are available. **Arcom Control Systems Inc,** Kansas City, MO. **Circle No. 484**

Test-probe catalog. A 28-pg catalog describes the firm's line of spring-loaded test probes that are used with in-circuit board-test systems. Included are SMT and high-current probes. **Ostby Barton,** Warwick, RI. **Circle No. 485**



Motion-controller catalog. The 24-pg Galil Motion Control Product Catalog provides information on motion controllers packaged as both industrial modules and as cards for PCs, VMEbus, and STD bus. A product matrix describes controller features for easy comparison and selection. The catalog also describes software tools for controller setup and analysis. **Galil Motion Control Inc,** Sunnyvale, CA. **Circle No. 486**

Sensor catalog. Catalog S-02-A is a 40-pg catalog providing detailed specifications on electronic sensors. Included are pyroelectric infrared sensors, magnetic angle sensors, rotation sensors, ultrasonic sensors, and magnetorestrictive sensors. Also included is a selection of temperature sensors and PTC and NTC thermistors. Both electrical and mechanical specifications are detailed, as is application information. **Murata Erie North America,** Smyrna, GA. **Circle No. 487**

DC/DC-converter application note. This 6-pg application note details dc/dc-converter theory of operation. Topics covered include pulse-width modulation, isolated and nonisolated circuit topologies, input-output circuits, and isolation and protection circuits. A number of illustrations complement the written discussions. **Conversion Devices Inc,** Brockton, MA. **Circle No. 488**

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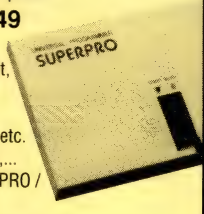

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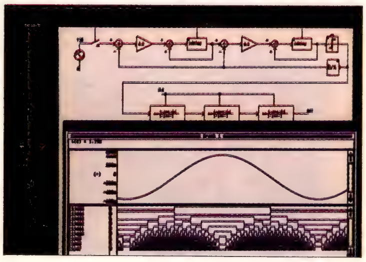

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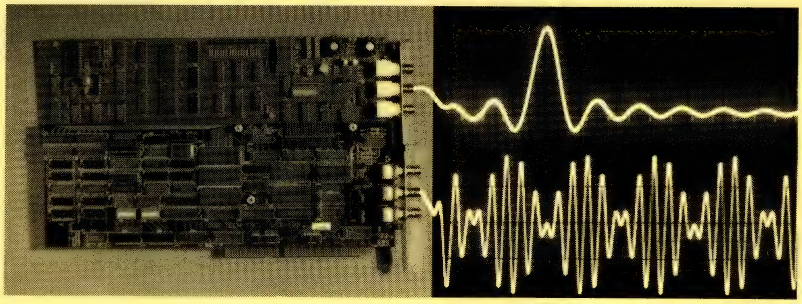

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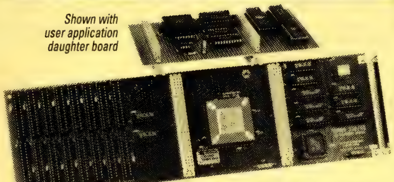

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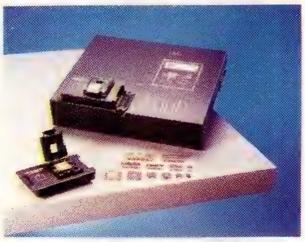

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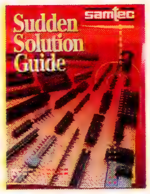

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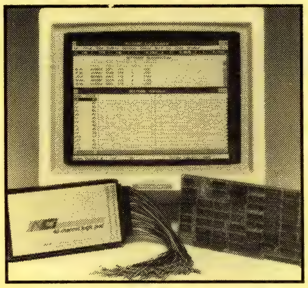

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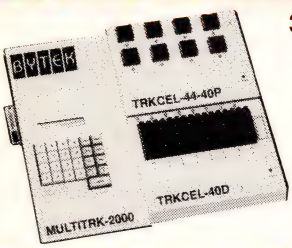

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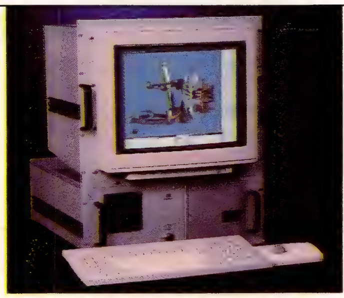

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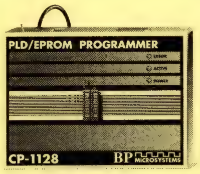

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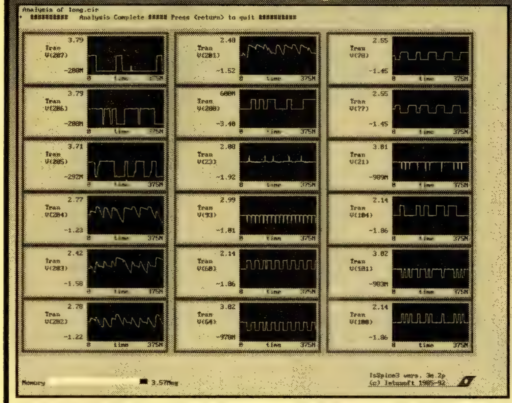

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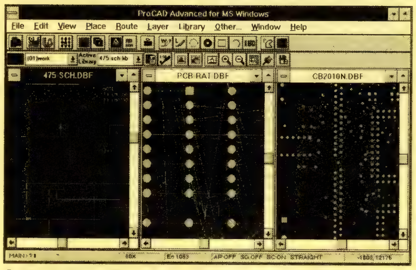

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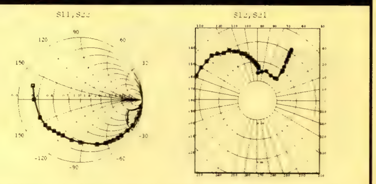

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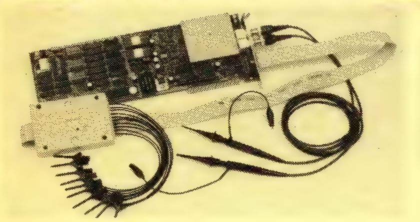

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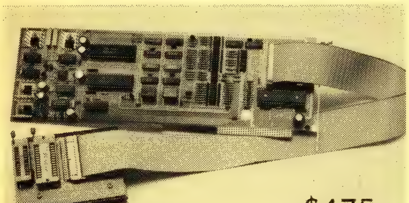

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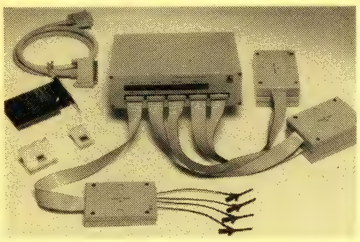

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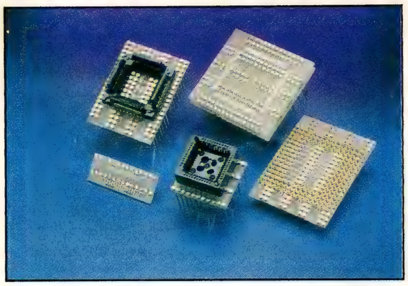

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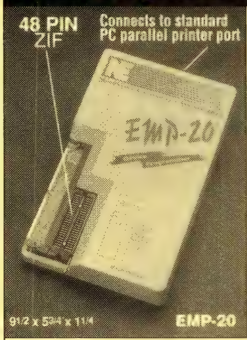

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CIRCLE NO. 271

Book explores how to take charge of your career

The book *If you want guarantees, buy a toaster*, by Robert M Hochheiser, is about managing your career. It is about misplaced loyalties. And it is about finding your place in a changing business environment. As I turned the pages of this book, many conflicting thoughts swept through my mind. Its discussions of office politics sometimes touched my own experiences. Its lessons in pleasing the boss struck me as either good common sense or blathering silliness. (Dickens' Uriah Heep used some of the book's ploys in *David Copperfield*, and look what happened to him.) Throughout it all however, I perceived that the author was trying to present his reality to me.

As the book's title indicates, the job market in the 1990s offers no guarantees. Bosses come and go. Companies are born; some die. Wage freezes and pay cuts are constantly in the news. Seemingly permanent no-layoff policies suddenly vanish. Pensions go up in smoke. Contracts are broken. Mergers and takeovers occur. All of these events affect your job and your career. Hochheiser says you can drive or at least manage the changes that affect you or you can let events control you. Either way, the changes will occur.

The book's first chapter, "The facts of life," lays the author's reality of change before you. No amount of studying the world's economic position, your country's posture, or your company's strength will prevent change from affecting you. No position is permanently safe. At any time, a resignation or a promotion can replace your boss or someone vital to your job. How well you manage this change will depend on your preparedness. The remainder of the book dwells on techniques you can use to prepare for change.

The book's main point is that you should always work for yourself, even when you're not self employed. You should do those things that move you toward your goals whether or not you find them pleasant. Note however, that most activities that move you toward your goals should be pleasant. Otherwise, they're not really fulfilling your goals.

Many technical professionals like their business affairs to be neat and tidy. They feel that egos, politics, and human frailties should play no role in advancement. Perhaps you're like that. Unfortunately, the world doesn't work that way in any business field, including the electronics industry. Change is an integral part of the high-technology business. Though it may cause you some mental discomfort, reading this book will help you ride change instead of change riding you.

—Steven H Leibson

Robert M Hochheiser, "If you want gurantees, buy a toaster," William Morrow & Co, New York, NY, 1991, $18.

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